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EAST ASIAN SEAS
REGIONAL COORDINATING UNIT
UNITED NATIONS ENVIRONMENT PROGRAMME

Transboundary Diagnostic Analysis for the South China Sea

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PREFACE

Countries of the South China Sea do not exist in isolation nor are they able to retain the impacts of their activities within their national boundaries. The environment is not checked by national boundaries nor is it a limitless resource that can be exploited without restraint. It becomes obvious, as this report is read and understood that the countries bordering the South China Sea have exploited the coastal resources far beyond their capacities and that, without some intervention now, they will be destroyed forever. Marine biodiversity, carbon sequestration, nursery areas for fisheries, buffer zones from the ravages of storms are all being lost and the plunder continues. This report is an inventory of the cross-boundary pollution and destruction of marine habitats that covers the South China Sea.

The national transboundary diagnostic analysis reports of seven countries participating in the Global Environment Facility South China Sea Project were analysed and summarised to prepare this report. The countries concerned are Cambodia, China, Indonesia, Malaysia, Philippines, Thailand and Viet Nam. For only two of these, Viet Nam and Cambodia, are the entire coastlines used in the report. For the others, only the coast that borders the South China Sea is included. Ideally, the country reports from which this report was compiled were prepared under the same guidelines, for some countries this was not so easily done nor rigidly adhered to, the result being lack of data or inconsistent data. The national TDAs are available from UNEP EAS/RCU.

This report, contained the most up to date information available from the participating countries, including major environmental problems in the South China Sea, transboundary analysis and sources and causes of these problems. It is a useful document for preparing project proposals, reporting on the state of the environment and as a general guide to the use and misuse of the coastal waters of the South China Sea. Environmental planners, managers and academics may find this report useful for case studies and for data.

Hugh Kirkman
Coordinator, East Asian Seas Regional Coordinating Unit

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TRANSBOUNDARY DIAGNOSTIC ANALYSIS FOR THE SOUTH CHINA SEA

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1 BACKGROUND

1.1 Global and regional significance of the South China Sea and its associated freshwater catchments

The South China Sea is a strategic body of water that is surrounded by nations that are currently at the helm of industrialization and rapid economic growth in the Asia-Pacific region. Bordered by the People's Republic of China to the north, the Republic of the Philippines to the east; Malaysia, the Republic of Singapore, the Republic of Indonesia and the Sultanate of Brunei to the south; the Kingdom of Thailand, the Kingdom of Cambodia and the Socialist Republic of Viet Nam to the west; the South China Sea has always been central to issues of economic and political stability in Southeast Asia and adjacent regions. Today, it is central to defining environmental sustainability and food security for its coastal nations.

Seven littoral states are included in this analysis which is aimed at identifying and weighting water-related problems and concerns in the South China Sea. These are China, Viet Nam, Cambodia, Thailand, Malaysia, Indonesia and the Philippines. The coastal subregions of these nations are home to 270,000,000 people or 5% of the world's population. About 122 major rivers drain 2.5 X 10^6 km^2 of catchment area and deliver materials, nutrients and pollutants to the South China Sea (data compiled from National TDA Reports).

The Indo-West Pacific marine biogeographic province has long been recognized as the global center of marine tropical biodiversity. Forty-five mangrove species out of a global total of 51 (Spalding *et al*., 1997); 50 of 70 coral genera (Tomascik *et al*., 1997); 20 of 50 seagrasses species (Sudara *et al*., 1994); and 7 of 9 giant clam species (Tomascik *et al*., 1997), are found in the nearshore areas of the South China Sea. Compared to the Atlantic, the tropical Indo-West Pacific is highly diverse. Only 5 mangrove species and some 35 coral species are found in the Atlantic compared with 45 mangrove and over 450 coral species recorded from the Philippines, 200 from the Red Sea, 117 from South East India and 57 from the Persian Gulf.

Recent estimates suggest that approximately 2 million hectares of mangrove forest or 12% of the world total are located in the countries bordering the South China Sea. This represents only 31% of the estimated total found in these countries at the start of this century (National TDA Reports). Estimated rates of loss in each country range from around 0.5 to 3.5% of the total area per annum and at these present rates could result in total loss of this habitat in the region by around 2030. Chou *et al*., (1994) estimate that 82% of the coral reefs surveyed in the South China Sea display evidence of degradation while Bryant *et al*., (1998) suggest that 50% of the Philippine and 85% of Indonesian reefs are at high risk. Comparable estimates for degradation of seagrass habitats are not available but are unlikely to be as high as this.

The high species diversity of the shallow water habitats in this region combined with the variation in geomorphic and geological settings, and formation types, contribute to the global significance of these habitats.

This richness in flora and fauna is accompanied by the area's high natural productivity. Capture fisheries from the South China Sea contribute 10% of the world's landed catch at approx. 5 X 10^6 tons $year^{-1}$ (Pauly and Christensen, 1993). From the standpoint of aquaculture, five of the eight top shrimp producers in the world, are border states of the South China Sea. These are Indonesia (first), Viet Nam (second), China (third), Thailand (sixth), and the Philippines (eighth) (Menasveta, 1997).

The richness and productivity of the South China Sea and associated environments are, however, seriously threatened by high population growth, pollution, overharvest and habitat modification, resulting in high rates of habitat loss and impairment of the regenerative capacities of living resources. The socio-economic impacts of environmental deterioration are significant for the newly developed economies of this region. While GDP is newly dominated by the industry and service sectors, food consumption patterns rely heavily on cheap protein derived from fishery resources. The agriculture sector (including fisheries) remains a source of significant revenue and an important domestic source of food.

1.2 Purpose of the Transboundary Diagnostic Analysis (TDA)

The transboundary diagnostic analysis of the South China Sea and its associated catchment areas, is a process that focuses on identifying water-related problems and concerns, their socio-economic root causes, and the sectoral implications of actions needed to mitigate them. The analysis further seeks to determine those issues which have transboundary, i.e. involves more than one country, causes and/or impacts, appropriate mitigation of which will have to be done on a regional or bilateral basis. The analysis then becomes the basis for a strategic action program which is coordinated both at the national and regional levels.

1.3 Process of the TDA

In this TDA, national committees were formed through the initiative of the UNEP national focal points in each of the seven countries. Headed by a coordinator, each national committee was asked to prepare a country report that would provide a country-based analysis of water-related problems and concerns. To brief the seven coordinators, a first meeting was held in March 1997, during which the outline of the country reports was prepared and accepted by the group.

The first drafts of the national reports were submitted and evaluated prior to a second meeting of the national coordinators that was held in June, 1998. During this meeting, and on the basis of the causal chain analysis done by each country for each identified water-related problem, a weighting of all identified major issues was made *en banc* by the national coordinators and invited scientists from the region. The weighted issues and problems are shown in Table 1.1.

Table 1.1 Preliminary ranking of major concerns and principal issues for the South China Sea (Annex V, Second Coordinators Meeting, June 1998.)

Major Concerns	Score	Rank	Principal Issues	Score	Rank
Habitat	18.5	1	Mangroves	21	1
			Coral Reef	20	2
			Seagrasses	17	6
			Estuaries	16	7
Over exploitation	17.5	2	Marine	19	3
			Freshwater	16	7
Pollution	14	3	Sewage	19	3
			Freshwater Contamination	17.5	5
			Agricultural loading	15	9
			Industrial Waste	15	9
			Sedimentation	14	11
			Solid Waste	13	12
			Hydrocarbon	12	13
			Ship-based sources	12	13
			Atmospheric	8.5	16
Freshwater concerns	9	15			

The identified regional concerns and principal issues became the foci for the preparation of the outline for this regional transboundary diagnostic analysis, which like the outline for the national reports, was deliberated upon and accepted by the national coordinators and the regional resource persons. Along with the preparation of the TDA outline, the substance of the strategic action programme was discussed.

The national reports, the transboundary diagnostic analysis and the strategic action programme are key elements in a project development activity under the Global Environment Facility (GEF) International Waters Portfolio. A project brief was developed in this analytical and participatory process, that provided mechanisms for the implementation of actions addressing the major water-related issues in the South China Sea.

2 BIOPHYSICAL AND SOCIO-ECONOMIC SETTING OF THE SOUTH CHINA SEA AND ITS ASSOCIATED FRESHWATER CATCHMENTS

2.1 Physical setting

2.1.1 Geographic subdivisions used in the TDA

The countries and watersheds relevant to the South China Sea and this report are shown in Fig. 1. The detailed geographic subdivisions used in the TDA are shown in Table 2.1, and a summary of pertinent statistics are indicated in Table 2.2. The subdivisions include 93 cities, each with a population of more than 100,000. Approximately 122 rivers running through the seven participating countries, and draining a total catchment area of 2.5 million km^2, empty into the South China Sea. The area of watershed drained by the rivers is almost twice that of the total area of the subregions, since a number of rivers such as six which enter the Viet Namese coastal waters, are transboundary.

Figure 1 The countries of the South China Sea.
National boundaries and shoreline are shown by solid lines.
Shaded areas represent sub-divisions where data were analyzed in the TDA.

Table 2.1 Geographic subdivisions of the TDA-participating countries which interact with the South China Sea.

Country/ Subregion	Major Cities	Major rivers	Watershed area (10^3 km^2)	Area of subregion (10^3 km^2)	Population of subregion (10^3)
Cambodia:					***1997***
Koh Kong	Koh Kong	Stung Metoek	1.14	11.16	105
		Stung Russei Chrum	2.73		
		Stung Sala Munthun	1.57		
		Stung Chhay Areng	2.11		
Sihanouk Ville	Sihanouk Ville	Prek Piphot	1.16	0.87	132
		Prek Kompong Som	2.64		
Kompot	Kompot	Prek Toeuk Chhou	2.06	5.21	603
Subtotal	**3 cities**	**7 rivers**	**13.41**	**17.24**	**840**
China:					***1995***
Guangdong	Chaozhou, Shantou, Jieyang, Shanwei, Huizhou, Shenzhen, Dongguan, Guangzhou, Zhongshan, Zhuhai, Jiangmen, Yangjiang, Maoming, Zhanjiang	Han	30.11	83.33	47,919
		Rong	4.41		
		Pearl	442.10		
		Moyang Jian	6.09 6.09		
Guangxi	Beihai, Qingzhou, Fangcheng Port	Nanliu	8.64	20.36	5,088
		Qing	2.46		
		Maoling	2.96		
Hainan	Haikou, Sanya	Nandu	7.02	33.92	5,733
		Changhua	5.15		
		Wanquanhe	3.69		
Hong Kong	Hong Kong	None	None	1.07	6,190
Macau	Macau	None	None	0.02	424
Subtotal	**21 cities**	**11 rivers**	**518.72**	**138.70**	**65,354**
Indonesia					***1994***
Riau-Batam	Tanjung Pinang	none	none	94.56	3,648
Bangka-Belitung and South Sumatera	Pangkal Pinang, Palembang	Musi	9.13	103.69	6,997
Jakarta and West Java	Jakarta	Ciliwung-Cisadne	2.24	46.89	47,547

Continued Table 2.1

Country/ Subregion	Major Cities	Major rivers	Watershed area (10^3 km^2)	Area of subregion (10^3 km^2)	Population of subregion (10^3)
East Java	Surabaya	Brantas	12.00	47.92	34,758
South Kalimantan	Banjarmasin	Barito River	32.00	37.66	2,804
West Kalimantan	Pontianak	Kapuas River	5.00	146.76	3,616
Subtotal	**7 cities**	**5 rivers**	**60.37**	**477.48**	**99,370**
Malaysia					***1991***
Kelantan	Kota Bharu	3 rivers	15.02	14.92	1,208
Terengganu	Kuala Terengganu	9 rivers	12.97	13.00	809
Pahang	Kuantan	5 rivers	42.24	35.97	1,081
Johor	Johor Baru	4 rivers	7.44	18.99	2,162
Sabah	Kota Kinabalu	11 rivers	31.31	73.62	1,809
Sarawak	Kuching	19 rivers	122.45	123.98	1,718
Subtotal	**6 cities**	**51 rivers**	**231.43**	**280.48**	**8,787**
Philippines					***1995***
Western Luzon	Laoag, Dagupan, Olongapo, Metropolitan Manila (7 cities) San Pablo, Cavite, Batangas	Laoag	1.32	29.27	22,653
		Abra	5.12		
		Agno	5.95		
		Pampanga	9.76		
		Pasig-Marikina-Laguna de Bay	5.28		
Mindoro Occidental		none	none	5.88	339
Palawan	Puerto Princesa	none	none	14.90	640
Subtotal	**16 cities**	**5 rivers**	**27.43**	**50.05**	**23,632**
Thailand					***1997***
Northern	Chiang Mai, Nakorn Sawan	Salawin	17.9	171.50	12,091
		Ping	33.90		
		Kok	7.89		
		Wang	10.79		
		Yom	23.62		
		Nan	34.33		
		Khong	57.42		
Central	Bangkok, Nonthaburi, Patumthani, Samut Prakan, Samut Sakorn, Saraburi	Chao Phraya	20.12	64.04	14,350
		Sakakrang	5.19		
		Pasak	16.29		
		Ta Chine	13.68		
Eastern	Chonburi, Rayong	Prachine buri	10.48	36.50	4,065
		Tonlasap	4.15		
		Eastern coastal	13.83		

Continued Table 2.1

Country/ Subregion	Major Cities	Major rivers	Watershed area (10^3 km^2)	Area of subregion (10^3 km^2)	Population of subregion (10^3)
Southern	Surathani, Nakorn Sri-Thammarat, Songkhla, Hatyai	Eastern coastal of South	26.35	49.89	6,636
		Tapee	12.22		
		Songkhla Reservoir	8.49		
		Pattanee	3.86		
Subtotal	**14 cities**	**18 rivers**	**320.51**	**321.93**	**37,142**
Viet Nam					***1996***
Northern Mountains	Quang Ninh	Bang Giang	4.56	5.94	813
		Kycung	6.66		
Red River Delta and Midlands	Hai Phong Thai Binh Nam Ha Ninh Binh	Thao	51.75	6.81	6,354
		Da	52.61		
		Lo	38.97		
		Red	154.72		
		Cau	6.06		
		Thuong	3.58		
		Luc Nam	3.07		
		Thai Binh	15.52		
Central Coastal Region	Thanh Hoa, Nghe An, Ha Tinh, Quang Binh, Quang Tri, Thua Thien Hue, Quang Nam-Da Nang, Quang Ngai, Binh Dinh, Phu Yen, Khanh Hoa, Ninh Thuan, Binh Thuan	Ma	28.37	51.22	8,500
		Chu	7.55		
		Ngan Sau	3.81		
		Hieu	5.33		
		Ca	27.22		
		Tra Khuc	3.18		
		Ve	1.26		
		Ba	13.81		
South Central	Ho Chi Minh, Ba ria-Vung Tau	Dong Nai	29.52	49.82	11,314
		La Nga	4.00		
		Be	8.20		
		Sai Gon	5.56		
Mekong Delta	Tien Giang, Ben Tre, Tra Vinh, Soc Trang, Kien Giang, Minh Hai	Se San	17.5	24.16	6,076
		Sre Pock	18.28		
		Cuu Long (Mekong)	65.00 (777.00)		
Subtotal	**26 cities**	**25 rivers**	**576.09 (1353.09)**	**137.95**	**33,057**

Table 2.2 Geographic subdivisions of the TDA-participating countries which interact with the South China Sea. (Summary)

Country	Major Cities (>100,000 population)	Major rivers	Watershed area (10^3 km^2)	Area of South China Sea subregion (10^3 km^2)	Population of subregion (10^3)
Cambodia	3 cities	7 rivers	13.41	17.24	840
China (includes Hong Kong & Macau)	21 cities	11 rivers	518.72	137.70	65,354
Indonesia	7 cities	5 rivers	60.37	477.48	99,370
Malaysia	6 cities	51 rivers	231.43	280.48	8,787
Philippines	16 cities	5 rivers	27.43	50.05	23,632
Thailand	14 cities	18 rivers	320.51	321.93	37,142
Viet Nam	26 cities	25 rivers	1,353.09	137.95	33,057
Total	**93 cities**	**122 rivers**	**2,524.96**	**1,422.83**	**268,182**

2.1.2 Geomorphology and geological history

The Indian subcontinent collided with the Eurasian plate in the Late Eocene, and led to the rifting of the Sunda Shelf including Borneo, the Malaysian Peninsula and Palawan microplate. The rift is hypothesized to be the origin of the northwest sub-basin of the South China Sea (Brias *et al.,* 1993; Taponnier *et al*., 1982). North-south spreading occurred 27 to 16 Ma causing the formation of the eastern sub-basin of this marginal sea. The southwest sub-basin was formed 20 Ma, and spreading ceased around 15.5 Ma.

2.1.3 Circulation

Two basic features characterize circulation in the South China Sea. The first is the Indonesian throughflow of Pacific waters which interact with those influenced by the Indian Ocean while in the South China Sea. It is, in fact, a warmwater closure of global thermohaline circulation that is significant in distributing sea surface temperature as well as in providing for the air-sea fluxes of heat (Tomascik *et al*., 1997).

A second feature is a surface circulation that is heavily influenced by the Asian monsoon system, which affects the social and economic conditions of over 60% of the world's population (South China Sea Monsoon Experiment (South China SeaMEX) Science Plan, 1994). Surface currents flow north to south along the Viet Nam coast to the Java Sea during the northeast winds which blow from October to February (Wrytki, 1961). The flow reverses south to north along the western margin of the South China Sea during the southwest monsoon beginning in June.

The monsoonal system results from the location of the sea next to the land masses of Asia and Australia (Tomascik *et al*., 1997). Two opposing monsoons converge along the Inter-tropical convergence zone (ITCZ). This zone is displaced north or south depending on solar heating, driving the seasonal change from one monsoon to another. In December to January, there is high pressure over Asia and low pressure over Australia, pushing the ITCZ further south, and causing air to blow north to south. In June, pressure over Australia increases, and decreases over Asia, causing the ITCZ to shift north of the equator; and signaling the onset of the southwest monsoon.

A transition period occurs in March when the ITCZ is on the equator on its way northward, and when the Asian high weakens. Another slack period occurs in September with the weakening of the Australian high, and the movement of the ITCZ on the equator southwards.

The monsoonal system in the South China Sea modulates seasonal changes in pressure and interannual variability imposed by the El Ni駉 – Southern Oscillation. The arrival of Rossby waves carrying a warm water pool to the western margin of the equatorial Pacific is buffered by the South China Sea system. The consequences of extreme climatic changes resulting from this connection are dramatic for the resources and economies of the South China Sea states.

2.2 Biogeography

2.2.1 Biogeographic distributions

Mangroves. Mangroves occupy the humid tropical belt 30° north and south of the equator, with extensions beyond these latitudes in certain areas (Spalding *et al*., 1997). Two main centers of diversity have been identified. The eastern group includes the Indo-Pacific with its eastern limits in the central Pacific, and the western limits, along the southern tip of Africa. The western group includes mangroves found along the African and American coasts of the Atlantic Ocean, the Caribbean Sea and Gulf of Mexico, and the Pacific coastal areas of the Americas. The eastern group has about five times the species diversity recorded in the western region. Within this group, South and Southeast Asia contain 42 % of the global area occupied by mangroves, and harbor the highest diversity of mangrove species in the world.

Corals. Hermatypic or reef-forming scleractinian corals are widespread in the equatorial seas. Generic richness is highest (about 70 genera) in the Indo-Pacific center of diversity, which extends from the central Red Sea to east of Fiji (Veron, 1995). Species diversity is highest at around 450 species in the equatorial central Indo-Pacific defined by Sumatra and Java in the southwest; by Sabah and the Philippines in the northwest; and by the Philippines, eastern Indonesia and Papua New Guinea in the northeast. One-fourth of the world's charted reefs are located in this region of highest species coral diversity. Eighty percent of the reefs of Southeast Asia are exposed to medium and high risks imposed by coastal development, marine pollution, over-exploitation and destructive fishing, and land-based pollution and erosion (Bryant *et al.,* 1998).

Seagrasses. Generic richness of seagrasses is also centered in the Indo-West Pacific region (Heck and McCoy, 1978). Species diversity is highest in Malesia, a region defined by Indonesia, Borneo, Papua New Guinea and northern Australia. East Asia harbors the second highest number of seagrass species at 20 of 50 recorded species worldwide (Fortes, 1994, 1995; Sudara *et al*., 1994).

2.2.2 Evolutionary relationships

The biogeographic distributions of flora and fauna are consequences of evolutionary and ecological processes in geological history. Two types of geological events brought this about in the South China Sea region. The breaking off of microcontinents from eastern Gondwana which now form South East Asia and the northern portion of New Guinea, is believed to be a significant mechanism in transporting tropical fauna as these plates moved north and westward (Tomascik *et al*., 1997).

The second event was the formation of land connections and sea barriers, both of which act to impede larval dispersal, thus fragmenting species ranges and enhancing genetic isolation. A land barrier was created during the Cretaceous, connecting Laurasia to Australia. Another such barrier was formed with the collision between Sulawesi and Sula Peninsuls during the mid-Miocene, and created a continuous land mass between Laurasian Borneo and Gondwana New Guinea (12 MA to late Pliocene).

Geologically, two major theories are proposed to explain biogeographic affinities. Vicariance theory (McCoy and Heck, 1976) states that biota may have a historically wide range, which is modified by tectonic events, speciation and extinction. They used this theory in discussing relationships among seagrass, coral and mangrove species. Another theory called the Center of Origin theory, indicates that organisms increase their ranges by dispersal from a central point (Den Hartog, 1970).

For Veron (1995), the two are not mutually exclusive and both can be used in explaining coral affinities. He states that at the species level, the central Indo-Pacific is the center of diversity. Along a latitudinal gradient, there are sequences showing gradients from very high to very low species diversity, connected by boundary currents which flow poleward, taking equatorial propagules to high latitudes. The export of diversity from the equator can happen along evolutionary or ecological time frames. The evolutionary time frame seems to have an increasing influence eastward across the Pacific.

For mangroves, Spalding *et al*., (1997) state that distributions are largely relic and state that an eastern Tethys Sea origin seems to be suggested by fossils. Dispersal proceeded across the Pacific, and perhaps through the Panama gap into the Atlantic.

2.3 Socio-economic features

2.3.1 Demographic patterns

Table 2.3 Demographic and economic parameters by subdivisions in TDA participating countries

Country/ Sub-region	Area (10^3 km^2)	Population (10^3)	Annual population growth rate (%)	GDP (growth rate/y) (10^6 USD)	%GDP-Agriculture (growth rate/y) (10^6 USD)	%GDP-Industry (growth rate/y) (10^6 USD)
Cambodia (1996-1997)						
Koh Kong	11.16	105	8.33			
Sihanouk Ville	0.87	132	3.89			
Kampot	5.21	603	5.47			
Subtotal	17.24	840	5.58	0.12 (7%) (national)	45 (1.5) (national)	20 (14.1) (national)
China (1996)						
Guangdong	83.33	48,563	1.64	70,349	12.5 (8.1)	40 (nd)
Guangxi	20.36	5,148	1.29	2,989	40 (8.3)	20 (nd)
Hainan	33.92	5,983	1.55	4,177	34 (8.9)	21 (nd)
Subtotal	137.61	59,694	1.60	77,515	16	41
Indonesia (1995-1996)						
Riau & Batam	94.56	3,647	3.70	8,519	Nd	Nd
Bangka-Belitung & South Sumatra	103.69	6,997	3.02	5,827	Nd	Nd
Jakarta & West Java	94.81	47,547	2.89	59,272	Nd	Nd
S. Kalimantan	37.66	2,804	2.33	2,456	Nd	Nd
W. Kalimantan	146.76	3,617	2.50	2,856	Nd	Nd
Subtotal	477.48	99,370	2.90	78,930	13 (nd) (national)	38 (nd) (national)
Malaysia (1996)						
Kelantan	14.92	1,208	2.7	Nd	Nd	Nd
Terengganu	13.00	808	3.7	Nd	Nd	Nd
Pahang	35.97	1,081	2.8	Nd	Nd	Nd
Johor	18.99	2,162	2.5	Nd	Nd	Nd
Sabah	73.62	1,809	5.5	Nd	Nd	Nd
Sarawak	123.98	1,718	2.5	Nd	Nd	Nd
Subtotal	280.47	8,787	3.3	86,420 (national)	Nd	Nd

Continued Table 2.3

Country/ Sub-region	Area (10^3 km^2)	Population (10^3)	Annual population growth rate (%)	GDP (growth rate/y) (10^6 USD)	%GDP-Agriculture (growth rate/y) (10^6 USD)	%GDP-Industry (growth rate/y) (10^6 USD)
Philippines (1996)						
West Luzon	29.27	22,653	2.1	Nd	Nd	Nd
Mindoro Is.	5.88	340	3.5	Nd	Nd	Nd
Palawan Is	14.90	640	3.7	Nd	Nd	Nd
Subtotal	50.05	23,633	2.1	87,864 (national)	21 (nd) (national)	32 (nd) (national)
Thailand (1997)						
North	171.50	12,091	0.9	3,609	50 (nd)	33 (nd)
Central	64.04	14,350	1.4	62,532	4 (nd)	35 (nd)
East	36.50	4,065	1.8	10,248	12 (nd)	56 (nd)
South	49.89	6,636	1.8	7,455	36 (nd)	8 (nd)
Subtotal	321.93	37,142	1.4	83,844	10 (nd)	35 (nd)
Viet Nam						
Northern Mountains	5.94	813	Nd	Nd	Nd	Nd
Red River Delta and Midlands	6.81	6,354	Nd	Nd	Nd	Nd
Central Coastal	51.22	8,500	Nd	Nd	Nd	Nd
Eastern	49.82	11,314	Nd	Nd	Nd	Nd
Southern	24.16	6,076	Nd	Nd	Nd	Nd
Subtotal	137.95	32,558	1.6 (national)	97,000 (national)	Nd	Nd

A total of 270,000,000 people live in the coastal sub-regions of seven countries involved in the TDA process, and are concentrated in 93 cities, each with over 100,000 inhabitants (Tables 2.3 and 2.4). The weighted mean growth rate in the coastal South China Sea is 2.17%, which would double the population in 32 years. In Cambodia, Indonesia and Malaysia, growth rates in the South China Sea subregions are 1.5 to 2.0 times the national growth rates.

The population distribution largely determines the delivery of basic services and the quality of access to these. Population densities are highest for the coastal subregions of China and the Philippines at 471 and 472 pers km^{-2}, resp. Malaysia and Cambodia are least dense at 31 and 49 pers km^{-2}. Hinrichsen (1998) notes that in Viet Nam, people live at even higher densities of 500-1,000 pers km^{-2} along the northern part of the Gulf of Tonkin. In some parts of Hanoi, densities can reach 35,000 pers km^{-2}. He cites tourism, increasing fisheries efforts and oil exploitation as among the major economic driving forces behind this dramatic increase in coastal populations.

2.3.2 Regional economic characteristics

Table 2.4 Summary of demographic and economic parameters
(All data are for South China Sea related subregions)

Country/ Sub-region	Area (10^3 km^2)	Population (10^3)	South China Sea Annual population growth rate (%) (national rate)	Total GDP (growth rate/y) (10^6 USD)	%GDP-Agriculture (growth rate/y) (10^6 USD)	%GDP-Industry (growth rate/y (10^6 USD)
Cambodia (1996-1997)	17.24	840	5.58 (2.7)	0.12 (7%) (national)	45 (1.5)	20 (14.1)
China (1996)	137.61	59,694	1.60 (1.6)	77,515	16	41
Indonesia (1995-1996)	477.48	99,370	2.90 (1.5)	78,930	13 (nd) (national)	38 (nd) (national)
Malaysia (1996)	280.47	8,787	3.29 (2.0)	86,420 (national)	Nd	Nd
Philippines (1996)	50.05	23,633	2.13 (2.2)	87,864 (national)	21 (nd) (national)	32 (nd) (national)
Thailand (1997)	321.93	37,142	1.35 (1.0)	83,844	10 (nd)	35 (nd)
Viet Nam (1996)	137.95	32,558	1.60 (national)	97,000 (national)	Nd	Nd
South China Sea Total	1,422.73	262,024	2.17			

TDA participating countries are at various stages of industrialization (Table 2.4). Cambodia, with a national GDP of USD 0.12 million earns 45% of this from agriculture, and 20% from industry. In contrast, Indonesia relies on the industry sector for 57% of its GDP. In terms of increasing reliance on industry for the generation of GDP, the countries may be ranked as follows: Indonesia > China >Thailand > Philippines > Cambodia.

Table 2.5 Current and projected fish consumption
(national data cited by Silvestre and Pauly, 1997; 1998 World Almanac)

Country	Population 1996 (10^6)	Per capita GNP (USD, 1995)	Finite growth Rate (%)	Population 2005 (10^6)	Current Fish consumption (kg/p/y)	Total fish produced, 1994 (10^3 t/y)	Total fish required for food in 2005 at current per capita consumption (10^3 t/y)
Cambodia	10.2	215	2.7	13.0	12.0	103	156
Indonesia	197.6	940	1.5	225.9	15.5	4,060	3,502
Malaysia	20.6	3,930	2.0	24.6	29.5	1,173	726
Philippines	69.3	1,130	2.2	84.3	36.1	2,657	3,043
Thailand	61.4	2,680	1.0	67.2	25.3	3,432	1,699
Viet Nam	76.3	250	1.6	88.0	13.4	1,155	1,179

Using national data from 1995, the countries can be ranked based on per capita GNP as follows: Malaysia > Thailand > Philippines > Indonesia > Viet Nam > Cambodia (Table 2.5). For China, per capita GDP in 1994 was USD 2,500, which puts it between Thailand and the Philippines. Fish consumption is highest in the Philippines, and least in Cambodia. If one considers a minimum nutritional requirement of 21.5 kg/person/year, i.e. 50% of animal protein to be supplied by fish, Cambodia, Viet Nam, and Indonesia will need to increase per capita access to fish supply. To maintain the current pattern of consumption, total fish requirements in 2005 are shown in the last column of Table 2.5. Cambodia, the Philippines and Viet Nam will have to produce more fish just to meet domestic demands.

Table 2.6 Share of selected South China Sea countries in world exports of fishery products, in USD 1,000 (Ferdouse, 1994)

Country	1988	1989	1990	1991	1992
Indonesia	664,483	767,422	983,571	1,192,082	1,178,552
Malaysia	191,242	210,140	229,514	264,938	302,576
Philippines	407,504	409,879	395,960	467,729	393,997
Thailand	1,630,891	1,959,428	2,264,937	2,901,366	3,071,780
Brunei	300	350	380	440	400
Singapore	356,193	359,071	414,810	499,950	494,128
Total for 6 South China Sea countries	**3,250,613**	**3,706,290**	**4,289,172**	**5,326,505**	**5,441,433**
Global total	**31,804,116**	**35,886,233**	**39,539,969**	**43,546,408**	**45,451,914**
% of Global total	**10**	**10**	**11**	**12**	**12**

Table 2.7 Share of selected South China Sea countries in world imports of fishery products, in USD 1,000 (data from Ferdouse, 1994)

Country	1988	1989	1990	1991	1992
Indonesia	19,376	30,850	42,777	47,395	56,145
Malaysia	143,508	164,552	145,831	170,478	244,789
Philippines	63,063	65,730	84,809	96,109	111,000
Thailand	537,918	726,846	794,423	1,049,962	942,092
Brunei	7,404	7,180	7,160	6,780	7,000
Singapore	370,311	366,126	361,582	460,545	543,769
Total for 6 South China Sea countries	**1,141,580**	**1,361,284**	**1,436,582**	**1,831,269**	**1,904,795**
Global total	**35,269,622**	**35,886,233**	**39,539,969**	**43,546,408**	**45,451,914**
% of Global total	**3**	**4**	**4**	**4**	**4**

Despite nutritional requirements and current population growth rates, South China Sea countries in general are net exporters of fishery products. Because the need to generate foreign exchange to buy other capital inputs for industrialization is a higher priority than food security, this trade pattern will most likely continue, unless policy shifts occur to make food security of utmost importance in the national agendas of participating countries.

3 STATE OF ENVIRONMENT

3.1 Modification of habitats

3.1.1 Mangroves

Status and immediate causes of mangrove destruction. Mangroves in the seven participating countries constitute 10% of the current global area of slightly over 18 million ha (Fig. 2) (Table 3.1). The total area lost over different time spans (70 years for the Philippines) is estimated to be 4.2 million ha or 23% of the current global mangrove area. The causes of mangrove destruction include conversion to pond culture, tree felling for woodchip and pulp production, urban development and human settlements, and harvest of products for domestic use. The national impact of each economic activity is difficult to quantify for each country. Nonetheless, shrimp culture would seem to be the most pervasive economic imperative for mangrove conversion. A more thorough analysis must take into account the rate of loss brought about by each cause.

In a recent centre-page spread in the Jakarta Post the world's largest shrimp farm of 80,000 ha was described. It was claimed from mangrove at Bumi Dipasena. Integrated into the farm was a shrimp feed will producing 220 tonnes/year a hatchery producing 8 billion fry/year on a 220 ha site. Production of shrimp was estimated at 50,000 tonnes/year and 200 tonnes/day could be stored in a cold storage facility. There was a 160 megawatt power plant, waste water treatment plant, a port and housing estate for 110,000 people. The canals totalled 2,500 km.

Table 3.1 Loss and causes of mangrove destruction

Country	Original estimated cover (x 1000 ha)	Present area (x 1000 ha)	% Area lost	Causes of mangrove destruction			
				Shrimp culture	Woodchip, pulp, charcoal	Urban development / Human settlements	Domestic use
Cambodia	170	85	50	✓			✓
China	42	15	65	✓		✓	
Indonesia	N/A	936	N/A	✓	✓	✓	
Malaysia	505	446	12	✓	✓	✓	
Philippines	400	160	60	✓		✓	✓
Thailand[1]	280	160	57	✓			
Viet Nam	400	253	37	✓			✓
TOTAL		**1,852**					
GLOBAL TOTAL		**18,108**					

Sources: Spalding *et al*., 1997; *ISME* 1993; [1]MOSTE & The World Bank, 1999.

It should be noted that estimates of both original and present mangrove area vary greatly in the literature. Estimates used in this study are considered by the author to be the most reliable.

Transboundary issues. The major transboundary issues include losses in biodiversity and fisheries productivity, and the trading of cultured shrimps as well as woodchips and pulp. The quality of information to support the transboundary nature of these issues are assessed in the light of data provided by the national reports of the seven participating countries, and those accessed in the preparation of this analyses. The shrimp trade is well documented, while the loss of fisheries productivity is a major research gap. Trade of mangrove charcoal from Cambodia to Thailand is a major cause of mangrove loss in Cambodia (pers.comm. Phoeun Phean, Ministry of Agriculture and Fisheries, Cambodia)

Table 3.2 Transboundary issues resulting from mangrove destruction

Transboundary Issues	Countries Involved	Quality of information: G-good; F-fair; P-poor
Loss of biodiversity	All seven participating countries	F
Loss of fisheries productivity	“	P
Shrimp trade	All seven except Cambodia	G
Woodchip and charcoal	Indonesia, Malaysia, Cambodia	F

Loss of biodiversity. The incomplete inventory of flora and fauna associated with mangrove areas in the South China Sea region in the seven participating countries indicates the high biodiversity (Table 3.3). The rich species diversity is reflected in the high number of mangrove trees, finfish and penaeid shrimps, among others, that are associated with mangrove swamps. Because of the severe pressure exerted on mangroves, a number of associated species are among those classified as endangered (Table 3.4). These include the proboscis monkey, *Nasalia larvatus*, which eat young shoots and growing tips of *Sonneratia* and *Avicennia* trees, the crocodile *Crocodilus porosus* and swamp birds like *Ardea* and *Egretta* (Low et al., 1994).

Table 3.3 Biodiversity associated with mangroves

Country	Number of mangrove tree species[1]	Number of fish species[2]	Number of commercially exploited penaeid species[3]	Number of reptile species[4]	Number of bird species[4]	Number of mammal species[4]
Cambodia	42[5]				174[6]	
China	23					
Indonesia	45	138	42	7		43
Malaysia	36	99	28	7	60	19
Philippines	30	81	11	9	70	4
Thailand	35	67	20			
Viet Nam	28					

Sources: 1. Spalding *et al*., 1993; 2. Singh *et al.,* 1994; 3. Chong *et al.,* 1994; 4. Low *et al.,* 1994; 5. Pers. Comm. Kim Nong, IDRC, Cambodia; 6. Preah Sihanouk National Park Bird List.

Table 3.4 Endangered species occurring in mangroves in Southeast Asia (Low *et al*., 1994)

Species	Threat
Birds:	For all species:
➢ Purple heron *Ardea purpurea*	
➢ Dusky-grey heron *Ardea sumatrana*	Loss of habitat, hunting for feathers, reduction of food supply due to overharvesting of bird food sources by man
➢ Black-crown night heron *Nycticotrax nycticorax*	
➢ Black bittern *Dupetor flavicollis*	
➢ Great egret *Egretta alba*	
➢ Common bittern *Ixobrychus involucris*	
➢ Lesser adjutant stork *Leptoptilus javanicus*	
➢ Milky stork *Mycteria cinerea*	
➢ Common cormorant *Phalacrocorax carbo*	
Amphibians:	
Crab-eating frog *Rana cancrivora*	Loss of habitat
Reptiles:	
Saltwater crocodile *Crocodylus porosus*	Loss of habitat, hunting for skins
Mammals:	
➢ Long-tailed macaque *Macaca fascicularis*	➢ Hunting
➢ Malaysian flying fox *Pteropus vampyrus*	➢ Hunting
➢ Proboscis monkey *Nasalis larvatus*	➢ Loss of habitat
➢ Sumatran tiger *Panthera tigris sumatrae*	➢ Killed for skin and bones
➢ Leaf monkey *Presbytis cristata*	➢ Loss of habitat
➢ Javan rhinoceros *Rhinoceros sondaicus*	➢ Loss of habitat, hunting

Loss of fisheries productivity. Mangroves act as nursery and feeding grounds for finfish and shellfish at some stage or throughout their life cycles. Singh *et al*., (1994) obtained studies that show high correlation between catch in coastal fisheries and the area of adjacent mangroves in study sites such as Indonesia, Malaysia, Philippines, Australia and the US. Although correlation does not imply causation, ecological studies have established the connections between mangroves, coral reefs and seagrass as far as supporting the life cycles of coastal organisms (Robertson and Duke, 1987; Twilley, 1989). Based on the precautionary principle, it is not necessary to unequivocally prove that mangrove destruction will cause a decline in the productivity of dependent biota, and consequently a decrease in their yields. Until proven otherwise, then, mangroves must be conserved if only for their probable positive relation to coastal fisheries.

The loss of renewable living resources resource is difficult to evaluate and value. For the Philippines, the loss of mangroves and the consequent losses of their functions in fisheries and other ecological services have been estimated to be US\$242 Myr^{-1}.

Shrimp trade. Six of the seven participating countries accounted for 61% of shrimp exports to Japan in 1994, 74% of those entering Hong Kong, and 42% of those imported by Taiwan of China (Ferdouse, 1996) (Table 3.6). Other markets for shrimps include the USA and EU, and the emerging markets in Asia like Singapore and South Korea.

The dominance of South China Sea countries in global shrimp production and trade, underscores the richness of their resource base in supporting a highly valued fishery product (Table 3.5). It also highlights the economic imperative behind the desire of producing countries to keep the supply flowing, often without regard for the environmental impacts increased production would bring. International financing institutions like the Asian Development Bank have provided credit assistance to ASEAN countries in their bid to meet the high and lucrative demand for shrimps (Primavera, 1994; Menasveta, 1997). At the consumers' end, the desire for more prawns should not be regarded as a mere function of their high disposable incomes, but also and more critically, of the environmental sustainability of producing the fishery product they demand.

The increase in shrimp production, with the exception of the Philippines, in the last ten years can be seen in Table 3.5. However over the last four years the largest producer, Thailand, has reduced its production of shrimp and this trend may be continuing.

Table 3.5 Production of cultured shrimp (*Penaeus monodon*, Giant tiger prawn)

Country	1988 mt	1989 mt	1990 mt	1991 mt	1992 mt	1993 mt	1994 mt	1995 mt	1996 mt	1997 mt
Indonesia	44,450	63,676	67,355	96,811	98,358	87,285	83,193	89,344	96,237	99,680
Malaysia	1,105	1,965	2,184	2,895	2,821	3,937	5,789	6,713	7,412	9,380
Philippines	41,458	43,539	47,591	45,740	75,996	86,096	90,426	88,850	76,220	40,102
Thailand	40,774	81,492	107,970	155,069	179,358	219,900	259,724	257,062	220,372	211,100
Viet Nam	20,590F*	21,020F*	23,250F*	26,700F*	28,350F*	31,500F*	33,750F*	39,000F*	48,750F*	60,000F*
Total	**148,377**	**211,692**	**248,350**	**327,215**	**384,883**	**428,718**	**472,882**	**480,969**	**448,991**	**420,262**

Source: FOA Report on Fisheries Statistics P74 B-45
**. Estimates of FAO*

Table 3.6 Importation by major Asian markets of shrimp from participating countries, 1994 (data from Ferdouse, 1996)

Country	**Import of shrimp by major Asian Markets (mt), 1994**		
	Japan	**Hong Kong**	**Taiwan of China**
Indonesia	63,666	4,202	21
Thailand	49,345	6,470	10,574
Viet Nam	32,979	6,715	
China	20,417	6,531	
Philippines	16,916	37	
Malaysia	2,279	690	
Subtotal for 6 counties (% Overall Shrimp Import by Recipient Country)	**185,602 (61%)**	**24,645 (74%)**	**10,595 (42%)**
Overall shrimp import	**302,975**	**33,191**	**25,104**

Shrimp culture systems. Of the three culture systems used in shrimp production, extensive culture requires the largest space, is the major culprit in mangrove conversion, and is the least productive (Menasveta and Fast, 1998). However, the extent of environmental impacts by each culture system should be assessed in terms of clearance rates, area requirements, and in terms of adverse consequences such as the extent of water quality degradation, and pressure on water resources, among others.

Extensive farming dominates and is practiced in close to 70% of global pond area. Its low capital requirements and high dependence on tidal regimes for water and natural food inputs, requires extensive mangrove areas. To increase per unit area production, the semi-intensive technique was developed, basically augmenting natural food with supplementary feeds, and the tidal flushing with a pumping system (Primavera, 1993). The intensive culture system relies heavily on artificial feeds, pumps and aerators, and may not necessarily be sited in mangroves (Menasveta, 1997).

Using productivity and environmental impacts as criteria, Primavera, (1994) states that the sustainability of successful shrimp aquaculture will require the use of semi-intensive culture systems refined by environmentally sound practices, including the appropriate management of feeds and wastewater.

Table 3.7 World shrimp culture areas and annual production by culture system, 1992-1993 (Menasveta and Fast, 1998)

Culture System	**Pond Areas**		**Annual Shrimp Production**	
	Area (ha)	**% of Total**	**Production (mt)**	**% of Total**
Extensive	726,900	67	159,900	22
Semi-intensive	304,000	28	304,000	42
Intensive	52,000	5	258,800	36

Shrimp culture and the introduction of exotic species. Another transboundary issue is the introduction of pathogens with the trade of brood stocks and larvae for shrimp hatcheries and grow-out ponds worldwide (Primavera, 1993). Furthermore, introduction of exotic penaeid species which promise higher growth rates and thus, higher economic returns has also occurred. In the Philippines, *Penaeus vannamei* and *P. stylirostris* from Panama were introduced to ponds in the central islands in the 1970s. *P. chinensis* from China and a stock of *P. vannamei* from Hawaii were brought in in the ‘80s and ‘90s, respectively. (Primavera, 1993). While the environmental impacts of such introduction have yet to be documented, the spread of disease and parasitic infestation that is exacerbated by poor pond management, may be symptomatic of the effect of importing foreign stocks.

Shrimp culture and trade of chemically contaminated products. The wide use of chemical products in shrimp culture, and residuals that have chemical lives long enough to threaten public health, is another associated transboundary issue. Srisomboon and Poomchatra, (1995) warn of the contamination of traded shrimp products with antibiotics and their transboundary transport. The tetracycline group of antibiotics, for example, can inhibit protein synthesis in mammalian cells, and can cause acquired resistance to a broad spectrum of microorganisms. The presence of antibiotic residues has occasionally led to the rejection of shipments from South China Sea countries, causing economic losses for exporters. It also is indicative of how far removed the production systems are from natural systems which allow organisms growing in the wild to cope with naturally occurring pathogens.

Export of wood products (logs, chips and charcoal). Unlike shrimps which are produced mainly for export, wood products derived from mangroves are consumed both by domestic and foreign markets. Because of the high revenues derived from export, it is economically more gainful and often, more environmentally threatening, when foreign demands become a market priority. Table 3.8 shows the exported wood products by three participating countries (Indonesia, Malaysia and Thailand) with data obtained from ISME, (1993). Among the wood-based activities, woodchips for use in the Japanese rayon production, seems to be the most destructive and least sustainable. Closure of operations of chip plants at levels below optimum because of extremely rapid consumption of mangrove trees has occurred. The non-banning of the woodchip industry and reliance on shortage of raw materials for their short-term but devastating operation, underscores the heavy weight of profit over environmental non-sustainability in defining harvest policies for mangroves.

Table 3.8 Export of mangrove derived wood products (data from ISME, 1993)

Exporting Country	**Wood Product**	**Recipient countries**	**Details**
Indonesia	Logs from Sumatra, Kalimantan and Irian Jaya	Taiwan of China, Japan	1989: 34,404 m^3 out of 45,805 m^3 produced in West Kalimantan exported
	Charcoal from Riau Province in Sumatra with 836 kilns in 1984	Singapore, Hong Kong	1983: 1983 production reached 22,207 t, valued at USD 1 M.
	Woodchips and pulp from W. and E. Kalimantan, N. Sumatra	Japan	1990: 247,497 m^3 exported
Malaysia	Woodchips from Sarawak and Sabah	Japan	Lifespan of woodchip mills ranged from 15 to 25 years because of rapid consumption of mangrove stands (e.g. 70,000 ha in 15 yrs.) with USD 3-5 M annual revenue
Thailand	90% of harvest used for charcoal; 60% of charcoal production for domestic consumption; 40% for export	Penang, Malaysia; Singapore and Hong Kong	Average harvest of wood is 783,780 m^3/yr to produce 387,800 m^3 of charcoal

3.1.2 Coral reefs

Status of coral reefs and immediate causes of degradation. Coral reefs in the seven participating countries are at various levels of degradation (Table 3.9). In sub-regions interacting with the South China Sea, reefs in Malaysia and northwest Philippines show 10 to 30 % degradation. In Thailand and Indonesia, 40 to 60% of reefs are degraded. Ninety five percent of coastal areas of Hainan are severely degraded.

Table 3.9 Extent of coral reef degradation in participating countries

Country/ Subregion of South China Sea	**% Degraded Reefs[1]**	**No. of transects[2]**	**Extent of Live coral cover (national scale and includes non-South China Sea subregions)**

			% Transects with >75% live cover	% Transects with 50-75% live cover	% Transects with 25-50% live cover	% Transects with <25% live cover
Cambodia	No data	36				
China (Hainan coast)	95					
Indonesia • Western • Central	 • 60 • 40	190	2.6	24.2	31.6	41.6
Malaysia • Peninsular • Eastern	 • 10 • 30	193	11.4	52.8	27.5	8.3
Philippines • Luzon • Palawan • Rest	 • 30 • 10 • 20	238	1.3	7.5	49.2	42.0
Thailand • North Gulf • South Gulf	 • 60 • 50	178	16.9	42.1	34.8	6.2
Viet Nam	No data					
ASEAN	82					

[1,2]Chou *et al*., 1994b.

Using published information from the ASEAN-AUSTRALIA Living Coastal Resource Resources (LCR) Project, and with sites that include areas not interacting with the South China Sea, the Philippines and Indonesia have 91 and 72% of the transects studied with less than 50% live cover (Chou *et al*., (a), 1994: Chou *et al.,* (b), 1994b). Using a regionalized assessment, Bryant *et al*., (1998), show that Southeast Asia harbors 27% of the world's mapped reefs, and that the reefs fringing the archipelagic nations of Indonesia and the Philippines, account for 84% of these (or 22% of the global total). Their evaluation indicates that 50% of Indonesian reefs and 85% of those in the Philippines are at high risk (Table 3.10).

The immediate causes of reef degradation in the participating countries and in Southeast Asia in general are varied, but the major ones are commonly identified in the national reports (Table 3.11). Regional assessments like those of Wilkinson *et al.,* (1994) state that pollution and sediments are major causes in countries of the Sunda shelf, and in the shallow areas of the Philippines and Indonesia. However, overfishing causes greatest degradation in the deeper areas of the archipelagoes including those in the oceanic shoals. Bryant *et al*., (1998) enumerate overfishing, destructive fishing practices, sedimentation and pollution associated with coastal development as the major culprits. These causes were weighted in determining the three risk levels used in their evaluation. They further note that, because reefs are most extensive and most threatened in Indonesia and the Philippines, the management steps taken by them will have a major impact on "…the global heritage of reef biodiversity".

Figure 3. Known distribution of coral reefs in the South China Sea categorized by the degree of human threats.

Table 3.10 Estimates of reef area and level of vulnerability to three risk levels (after Bryant *et al*., 1998)

Region	Coastal Population Density within 60 km from coast/km^2	Total estimated reef area (km^2)	Level of Risk		
			Low	***Medium***	***High***
Southeast Asia	128	68,100	12,300 (18%)	18,000 (26%)	37,800 (56%)
Indian Ocean	135	36,100	16,600 (46%)	10,500 (29%)	9,000 (25%)
Pacific	98	108,000	63,500 (59%)	33,900 (31%)	10,600 (10%)
Global Total		255,300			
Philippines	174	13,000	50 (0%)	1,900 (15%)	11,050 (85%)
Indonesia	93	42,000	7,000 (17%)	14,000 (33%)	21,000 (50%)

Table 3.11 Immediate causes of coral reef degradation (obtained from national reports).

Country	Immediate Causes			
	Over-exploitation	**Destructive fishing practices**	**Sedimentation**	**Pollution associated with coastal development**
Cambodia	✓	✓		
China	✓			
Malaysia	✓	✓	✓	✓
Indonesia	✓	✓	✓	
Philippines	✓	✓	✓	✓
Thailand	✓		✓	✓
Viet Nam	✓	✓	✓	✓

Transboundary issues. The transboundary issues associated with reef degradation include loss of biodiversity, reduction in reef fisheries, coastal tourism, threatened or endangered migratory species like marine turtles, the coral trade, and the trade of associated biota (Table 3.12). The quality of information to document or support the transboundary nature of these issues is generally fair.

Loss of biodiversity. Coral reefs are the most diverse of marine ecosystems. Table C5 summarizes salient taxonomic data for the region. Data is most dense in countries that were involved in the ASEAN-Australia LCR Project (Indonesia, Philippines, Thailand, Malaysia, and Singapore), and comparative data using similar methods for Viet Nam and Cambodia are needed. However, there is sufficient information to suggest that degraded reefs in studied areas have incurred reductions in biodiversity, and at worse, species extinctions. In Bolinao, northern Philippines, McManus *et al*., (1992), have shown the reduction in species diversity of reef fishes together with a decline in fish abundance as a consequence of overexploitation. In the same reefs, the sea urchin *Tripneustes gratilla* decreased dramatically in abundance from 210 per 100 m^2 in December 1987 to less than 1 per 100 m^2 March 1993. Consequently, there was a failure in recruitment, triggering the collapse of the sea urchin industry in 1992 (Talaue-McManus and Kesner 1995). It remains to be assessed how extinctions which are evident at local levels can impact biodiversity at larger scales.

The threats to fringing reefs of Southeast Asia are transboundary because of the high biodiversity they support. The reversing monsoonal pattern of wind and surface circulation provide for connections between oceanic shoal reefs and those which fringe the coastal states. McManus, (1994) hypothesizes that planktonic larvae of many coral reef biota from the oceanic shoals of the South China Sea can recruit in the fringing reefs of Sabah, the Philippines, Taiwan of China, coastal China, the Paracell Islands, Viet Nam or in the Natuna Islands (Indonesia), depending on the direction of water circulation. In protecting the regional biodiversity, it is imperative to take into account such connections. For example, the establishment of marine protected areas may be made more strategic within the context of interconnected reef systems and not as isolated non-interacting and self-contained units. One way to validate exchange of species and genetic biodiversity is through the examination of genetic affinities among conspecifics in various locations in the South China, with varying extent of larval dispersal. Those with short-lived larvae and therefore limited dispersal should have lower affinities, and those with long-lived pelagic larvae should have the closest genetic similarities. Ongoing studies in the region such as those being coordinated by ICLARM along with its collaborators in the region, and those conducted by the University of the Philippines Marine Science Institute South China Sea Program, can validate the reef connectivity hypothesis.

Table 3.12 Transboundary issues associated with degradation of coral reef

Transboundary Issues	Countried Involved	Quality of Information
Loss of biodiversity	All countries except Cambodia	Poor to Fair
Endangered or threatened migratory species – marine turtles	Indonesia, Philippines, Malaysia	Poor to Fair
Reduction in reef fisheries	Oceanic shoal reefs and associated coastal reefs (e.g. Viet Nam, China, Indonesia, Malaysia, Philippines)	Poor to Fair
Coastal tourism	All countries	Fair
Coral trade	Indonesia, Philippines as exporters	Fair
Trade of associated biota like aquarium fish	Indonesia, Philippines as exporters	Fair

Table 3.13 Biodiversity associated with coral reefs

Country	No. of scleractinian species	No. of fish species unique to country	No. of chaetodontid fish species in LCR study sites	No. of turtle species (all South China Sea species are endangered and migratory)
Cambodia	No data	No data	No data	4 sp
China • Hainan • Taiwan of China	 • 110 sp • 230 sp		No data	2 sp
Indonesia	350 sp, 76 genera	42 sp, 21 fam	33 sp	3 sp
Malaysia	346 sp	0 sp	21 sp	4 sp
Philippines	421 sp	294 sp, 42 fam	35 sp	4 sp
Thailand		50 sp, 24 fam	17 sp	2 sp
Viet Nam	350 sp, 79 genera	No data	No data	No data
ASEAN Region – LCR Study Sites		787 sp, 64 fam; 34 sp in 12 families common	41 sp	Worldwide total: 7 sp.

Sources: Alino, 1994, Chantrapornsyl, 1994, Chou *et al*., 1994 (a), Chou *et al*., 1994 (b), Ibrahim, 1994, Leh, 1994, Marquez, 1990, Palma, 1994, Soekarno, 1994, Soehartono, 1994, Ridzwan, 1994, IUCN, 1995.

Endangered and threatened migratory species. Four species of marine turtles nest in a number of localities around the South China Sea. Through tagging recoveries, migration patterns for a number of them are emerging. Limpus, (1994) states that marine turtles are likely to navigate across 2500 km relative to their nesting areas. Turtles from Sabah are recovered or captured in Eastern Indonesia or in the Philippines. Ibrahim, (1994) reports that tags from tagged leatherback turtles from Peninsular Malaysia have been received from Hawaii, Taiwan of China, Japan and Indonesia, but mostly from the Philippines. The reason for the high frequency of recovery in the Philippines is that leatherbacks may be following a north-bound current for their post-breeding migration.

Four marine turtle species (see Table 3.14) are exploited for their meat, eggs and shell. With their long life cycle, the long interval between egg-laying, their vulnerable nesting grounds, and the high natural mortality incurred at early stages, they are unable to cope with high exploitation rates. Table 3.14 shows annual populations of marine turtles in protected nesting sites in Terengganu, along the eastern coast of Peninsular Malaysia during the period 1984-1993 (Ibrahim, 1994). Hawksbills averaged 41 per year, leatherbacks and olive ridleys at 374 and 269 per year, resp. Green turtles were most numerous at 2,902 per year. Despite the differences in numbers, egg production across species did not vary much, from 83 eggs/female/year for leatherbacks to 112 eggs/female/year for hawksbills. Comparing the annual mean egg production with the annual mean number of nesting adults, adults represent 0.9% to 1.2% of the annual egg production of a nesting population. One may use this as a proxy to infer mortality rates. Thus, all four species incur mortality rates of 99% from egg to nesting adult, with little variation.

Table 3.14 Annual nesting of marine turtles in Terengganu (data from Ibrahim, 1994)

Year	Leatherback	Green	Hawksbill	Olive Ridley
1984	788	4,292	9	293

1985	418	1,169	20	380
1986	596	4,492	123	454
1987	502	1,459	23	493
1988	367	3,542	56	308
1989	286	2,213	20	280
1990	280	1,561	72	187
1991	207	5,311	25	121
1992	231	1,688	28	78
1993	63	3,296	38	98
Annual average nesting population /year	374	2,902	41	269
Annual average egg production, 1983-1993; eggs/yr	31,164	269,116	4,591	25,903
Average eggs/female /year	83	93	112	96
Annual adult numbers/ Annual egg production	1.2%	1.1%	0.9%	1.0%

Duc and Broad (1993) estimated that about 300 to 2000 hawksbill turtles were traded in various forms in three sites in southern Vietnam (Table 3.15). The upper limit of the estimate was consistent with that indicated by Mack et al. for the year 1977 (Table 3.16). Given the small nesting population of hawksbills and their low rate of egg production, it is likely that this level of exploitation is not sustainable.

Table 3.15 Exploitation of hawksbill turtles in Viet Nam, 1993
(data from Duc and Broad, 1993)

Study Site	**Captive-rearing for meat and shell**	**Capture of adults For meat and shell**	**Traded shell (kg; 1kg can be obtained from 1 adult)**	**Traded stuffed turtle**
Kien Giang Province: Total for 1993 was 308	173	56	20	59
Con Dao Archipelago, 1970s to 1985	50-100 killed/year			
Nha Trang : 2,000 pieces traded annually			150-200/ year	200-300/year

Turtle trade. Although the data in Tables 3.16 and 3.17 are twenty years old, these represent the level of exploitation incurred by the hawksbill turtle during the early years of the CITES Convention. Exports of raw tortoise shell from Southeast Asia accounted for almost 50% of the global annual trade in 1976 and 1977. In 1978, its share increased to 82% because of the 250% increase in Indonesian exports.

Imports of raw shells were also dominated by Asia, with Taiwan of China and Japan posting the highest from 1976 to 1978. It would be interesting to see the growth or demise of the trade considering the currently endangered status of marine turtles. The figures in trade in turtles need to be updated to determine changes in patterns of export and import, and to asses the level of commitment among parties to the CITES Convention to minimize the trade of endangered turtle species.

Table 3.16 Worldwide export of raw tortoise shell (kg) from *Eretmochelys imbricata* (Hawksbill turtle) (Mack *et al*., 1979)

Country	1976	1977	1978
Indonesia	71,373	85,577	219,585
Thailand	23,859	37,941	56,928
Philippines	15,607	27,905	38,145
Malaysia	7,253	8,879	9,311
Viet Nam	-	1,854	-
• **Total for SE Asia** • **% of World Total**	• **118,092** • **47%**	• **162,156** • **49%**	• **323,969** • **82%**
Total for Asia	141,294	265,875	329,984
Total for Oceania/Pacific Islands	55,547	1,310	36,871
Total for Central and South America	28,390	44,817	7,575
Total for Africa	9,801	3,811	3,660
Total for Caribbean	14,140	13,875	17,129
World Total	**249,172**	**329,688**	**395,219**

Table 3.17 Worldwide imports of raw tortoise shell (kg),1976-1978 (Mack *et al*.,1979)

Country	1976	1977	1978
Taiwan of China	46,652	37,704	128,846
Japan	46,060	45,818	44,039
Hong Kong	26,620	42,788	102,275
Malaysia	9,133	30,060	-
Singapore	4,140	21,002	18,469
China	3,911	3,381	3,827
Viet Nam	2,700	647	-
Thailand	1,238	2,231	-
• **Total for Asia** • **% of World Total**	• **140,454** • **75%**	• **183,631** • **71%**	• **297,456** • **96%**
Total for Europe	12,814	16,270	11,413
Total for Americas and Caribbean	23,181	11,875	194
Total for Pacific	14,000	50,714	252
World Total	**190,449**	**262,490**	**309,315**

Reduction in fisheries productivity. The transboundary nature of decreasing fisheries productivity in coral reefs can be viewed two ways. One way is to show transboundary impacts of declining fisheries in one country on another. The other way is to invoke that transboundary trade is an economic root cause of the reduction in reef fisheries productivity. Because there are very few studies addressing reef connectivities to date, it is difficult to prove the impacts of declining fisheries in terms of decreases in recruitment, growth and yield across national boundaries. The transboundary economic pressures bearing on the extraction of reef-based fishery products like corals, aquarium fish, and the exploitation of reefs for their aesthetic values by coastal tourism, are better documented as below.

It is important to show in this section that reef degradation does lead to significant losses in fisheries, whether or not such losses or the factors causing them are transboundary. Reef–based fisheries account for about 20-25% of the marine fish catch in developing countries like the Philippines and Indonesia (McManus, 1988). Because of their proximity to shore, fringing reefs are heavily exploited by subsistence fishers including gleaners, whose catch do not make it to fisheries logs. As such, the estimation of reef-based fisheries is at best rough and an undervaluation of real catches. In a Philippine marine protected reef, Russ, (1991) estimated fish yield to be in the order of 30 mt/km^2/yr. In a heavily exploited Philippine reef, McManus *et al*., (1992) found production values of 2.7 mt/km^2/yr and 12.0 mt/km^2/yr for the reef slope and reef flat of Bolinao, resp. Thus, overexploitation leads not only to degraded reefs with lower biodiversity, but also to habitats with lower capacities to support fish.

The losses, both in biodiversity and in fisheries yield, are transboundary if reef interdependence between oceanic shoals and highly exploited fringing reefs of the South China Sea is considered. The precautionary principle should be used to promote taking collaborative management steps despite the absence of unequivocal empirical data, which often comes too late for effective mitigation.

Coastal tourism. Tables 3.18 and 3.19 provide indications of the significance of tourism in generating foreign revenues. At the same time, the industry requires infrastructure, usually situated on the coast to maximize returns from the enjoyment of white sand beaches, and coral reefs. Tourism, including resort building and pollution caused by tourist activities, according to Wilkinson and Ridzwan, (1994), is ranked as a moderate threat to coral reefs in the ASEAN context. Sudara *et al*. (1994), underscore the fact that tourism is the major reef-dependent activity that is increasing throughout the ASEAN countries. They note further that coastal tourist facilities in Pattaya Bay (Thailand), Pulau Seribu (Indonesia), and others in Malaysia and the Philippines, have wrought damage on coral reefs.

Damage begins with the construction of resort facilities, exacerbating the flow of erosional materials (Sudara *et al*., 1994). Beaches are fortified with sand mined from adjacent reefs, some of which needs to be dredged to create sandy bottoms and navigation channels for boats. In certain cases, artificial beaches are made through reclamation. In all cases, sediments flow unabated to the fringing reefs causing smothering.

More negative impacts ensue when the facilities begin operations. Untreated sewage flows directly from discharge pipes to the reef flats and solid wastes begin to accumulate. For China-South China Sea, foreign tourists in 1996 were 9.0% of the resident population; 7.2% in Malaysia-South China Sea (1993); 6.7% in the Philippines-South China Sea (1993); and 32.6% in Thailand (1997).

Hawkins, (1998) provides a mechanism for linking tourism-generated income and coral reef conservation, a way of internalizing environmental cost into the industry through user fees, concession fees and other forms of service-money exchanges. Where subsistence people use the coastal land and waters for food and livelihood, the promotion of ecologically friendly tourism must not lead to their economic and social dislocation. Direct users have been integrated into conventional tourism as service providers, to supplement or broaden their income base, while the industry erodes the living resource and culture base. Innovative and integrated coastal management mechanisms may provide more appropriate linkages between stakeholders and the industry.

Table 3.18 Tourist visits in South China Sea-regions of the participating countries. National data was used for Cambodia, Indonesia and Viet Nam (World Tourism Organization, 1999). ([1]provided by national reports.)

Country	From same country	From South China Sea countries (% of foreign tourists)	From non-South China Sea countries (% of foreign tourists)	Foreign tourists	Total number of tourists
Cambodia, (National) 1998	9,659	72,301 (33%)	136,883 (65%)	209,184	218,843
China[1] –South China Sea, 1996	34,062,167	4,785,940 (81%)	1,105,954 (19%)	5,891,894	39,954,061
Indonesia (National), 1998	604,821	2,124,179 (48%)	2,307,271 (52%)	4,431,450	5,036,271
Malaysia[1]-South China Sea, 1993	1,193,837			636,846	
Philippines[1]-South China Sea, 1993	252,523	516,110 (33%)	1,058,308 (67%)	1,574,418	1,826,941
Thailand[1] –South China Sea, 1997	70,096,104	4,741,290 (39%)	7,387,241 (61%)	12,128,531	82,224,635
Viet Nam (National) 1998	540,971	437,217 (45%)	541,940 (55%)	979,157	1,520,128

The large number of tourists visiting Thailand is a warning to the authorities that care must be taken with the environment. As fledgling tourist industries begin in Thailand and Cambodia the governments are in a good position to manage the tourists and the industry. Note that most of the tourists visiting Cambodia are actually going to Tana Lot and not the coast (Table 3.18). There was a decline in tourism in South China Sea countries (World Tourism Organization, 1999) except for Thailand between 1997 and 1999, but the general trend is shown in Table 3.19.

Table 3.19 Growth in tourism in ASEAN countries, 1985-1992 (Sudara *et al*., 1994)

Country	1985 Million USD	1992 Million USD	Annual Growth %
Indonesia	548	2,723	56.7
Malaysia	622	1,595	22.3
Philippines	944	1,350	5.1
Singapore	1,600	5,782	35.5
Thailand	1,171	4,057	35.2

Coral trade. The export of corals from Southeast Asia, especially from Indonesia and the Philippines is a fairly well documented industry despite its illegality. From 1986 to 1989, export was not limited to these two countries, and included the significant contribution of Malaysia and Taiwan of China in certain years (Table 3.20). The ecological impact of harvest for the coral trade is localized damage (IUCN/UNEP, 1988). The transboundary aspect of the coral trade lies in the need for foreign exchange by Southeast Asian nations, among other tropical developing countries, and the need for exotic tropical ornaments by importing countries, which are developed nations like Japan, the US and those in Europe. Though legal instruments such as the coral ban in the Philippines, and the Lacey Act in the US should control illegal trade from the exporting country to the recipient country, these have not effectively stopped the coral trade. Bentley (1998) however, notes that the increase in exports by Indonesia could be explained in part by the void left by the Philippines as a result of the Philippine coral ban. The total shipment, in 1992, from the Philippines, totalled a million pieces (Table 3.21). The mean annual shipment leaving Indonesia during the period 1985-1995 reached 930,000 pieces. To date, the export of corals like coral mining for construction and for lime production, have not been banned in Indonesia. Bentley, (1998) underscores the fact that about 5,000 tons/year are harvested to meet the needs for local construction and lime production while 3,000 tons/year are for export.

Table 3.20 Coral trade by exporting/reexporting countries, 1986-1989
(based on Mulliken and Nash, 1993)

Country	**No. of pieces as reported by importing country**			
	1986	**1987**	**1988**	**1989**
Indonesia	280, 195	185,651	467,057	75,894
Philippines	750, 541	1,172,692	561,583	71,665
Singapore	7,986	230	161	75
Taiwan of China	78,442	263,706	106,051	168,641
Thailand	-	79	275	13
Malaysia	133,602	20 kg	-	-
Sri Lanka	74	72	65	398

Table 3.21 Coral shipments from the Philippines in 1992
(Mulliken and Nash, 1993)

Importing country	**No. of shipment s**	**Weight in tons**	**No. of pieces**	**Action of importing country**
Belgium	3		29,554	Accepted
Italy	3		27,190	Refused
Japan		1.3		Accepted
Netherlands	3		37,665	Accepted
	2	15.5	6886	Seized
UK	1		43,782	Refused
	2	56.5		Refused
USA	354			Accepted
	88			Abandoned
	39			Seized
	2			Returned
Total for USA	483		867,136	
Total for all countries	**497**	**>73.3**	**>1,000,000**	

Table 3.22 Average annual trade of Indonesian corals for the top 15 recipient countries, 1985-1995 (Bentley, 1998)

Importer	**Pieces**	**Importer**	**Pieces**
USA	676,531	Canada	5,730
Japan	114,219	Singapore	2,809
Germany (FR)	38,986	Austria	1,821
Spain	21,493	Hong Kong	1,671
Italy	20,540	Malaysia	1,258
France	17,275	New Zealand	1,051
Netherlands	11,030	Korea (Rep.)	978

UK	10,253	Other countries	3,802

Trade of marine aquarium fish. The trade in marine aquarium fish caught on coral reefs is unsustainable Cyanide and other harmful chemicals are used to make aquarium fish more vulnerable to capture. These compounds, however, harm reefs, especially in the Philippines and Indonesia where the trade provides lucrative but short-term gains. Although the sale of marine aquarium fish constitutes only 10% of the ornamental fish trade (90% freshwater), it is totally dependent on wild resources (Bassleer, 1994). Ninety-nine per cent are bought by hobbyists, while the remainder goes to public aquaria and research institutes. The Philippines and Indonesia appear to be the major exporters, with the US, the EEC nations and Japan as major trading partners.

The trade of coral reef resources for ornamental purposes is degrading to reefs in the South China Sea and other regions. Clearly, the driving forces are in the demand for these resources. At the sale and collection ends, environmental concerns may be increased through public education, regulations and more stringent management. Resor, (1998) considers environmental certificates as a means to promote best handling practices among collectors, who can then demand optimal prices for their catch. However, this assumes that reefs can sustain further harvest for use other than food. In summary, the gains for foreign exchange may be miniscule in comparison to rent that is dissipated with the loss of ecological functions like the ability of reefs to support fish for food.

Table 3.23 Trade of marine aquarium fish from Indonesia and Philippines (data from Bassleer, 1994)

Origin	**US imports (10^6 USD)**	**EEC Imports (10^6 USD)**	**Japan imports (10^6 USD)**	**Total 10^6 USD**
Indonesia	9.1	2.1	4.85	16.05
Philippines	8.6	1.3	3.85	13.75
Totals	**17.7**	**3.4**	**8.70**	**29.80**

Figure 4. Known distribution of seagrass in the South China Sea.

3.1.3 Seagrasses

Status of seagrass meadows and immediate causes of degradation. Among coastal habitats, seagrass beds are the least studied compared to coral reefs and mangrove systems (Fortes, 1994, 1995). An assessment of the extent of habitat modification in Southeast Asia is at best rough, and based on a few studied areas in each country. Anywhere from 20 to 50% of seagrass areas in Indonesia, Malaysia, Philippines and Thailand are damaged based on studies conducted by the ASEAN-Australia Living Coastal Resources Project and data provided by the TDA national reports (Table 3.24). Coastal development, which releases sediments, destructive fishing methods and land-based pollution, are among the major threats.

The lack of scientific information is alarming in the face of widespread modification of seagrass areas throughout the region. Their location in reef flats and areas adjacent to mangrove areas indicate their crucial function in trapping sediments which remain suspended after they pass through mangrove areas. Thus, seagrass beds are depositional areas themselves, and clean waters for corals. The shallow depths and proximity to shore render them extremely vulnerable to all forms of destructive harvest methods, and activities on land which exacerbate the release of sediments and effluents.

Table 3.24 Extent of damage and causes of degraded seagrass meadows

Country	**Extent of damage**	**Immediate causes of degradation**
Cambodia	No data	Fishing by pushnets, trawling, transport and navigation
China	4,200 ha remaining in Guangxi region	Land reclamation
Indonesia	30-40%	Sedimentation, heavy coral mining and collection from reef flats
Malaysia	Unknown	Coastal reclamation, oil spills, land-based pollution Adverse impacts of coastal reclamation in South China Sea regions
Philippines	30-50%	Industrial development, ports and recreation
Thailand	20-30%	Waste disposal from domestic use and aquaculture, fisheries, collection for traditional medicine, land reclamation and development
Viet Nam	Unknown	Fertilizer production, animal feed production, land reclamation for agriculture and aquaculture, mats and handicrafts

Sources: Fortes, 1994, TDA National reports

Transboundary issues. These include the loss of biodiversity, loss of fisheries productivity, and the trade of seahorses and marine turtles. The poor quality of information is a deterrent to a more quantified assessment of these issues, but their significance can be roughly determined given the information that can be accessed (Table 3.25).

Table 3.25 Transboundary issues resulting from degradation of seagrass habitats

Transboundary issues	Countries involved	Quality of information
Loss of biodiversity	All seven participating countries	Poor to Fair
Loss of fisheries productivity	Same	Poor
Seahorse trade	All except Cambodia	Poor
Marine turtle trade	All except Cambodia	Poor to fair

Loss of biodiversity. Like coral reefs and mangroves, seagrass beds are highly diverse. In Southeast Asia, 20 species of seagrasses have been recorded out of about 50 species worldwide, making the region the second most seagrass species-rich area next to Malesia, a region bounded by Indonesia, northern Australia and Papua New Guinea (Fortes, 1995). The number of adult and juvenile fish species which seagrass beds in the region harbor is high (Table 3.26). A number of endangered species like sea cows and marine turtles are known to feed in seagrass beds. (See discussion of marine turtles in section on coral reefs.).

Seagrasses, coral reefs and mangroves adjacent to or some distance from each other share similarities in biota because organisms spend various stages of their life cycles among these three coastal habitats. Siganids, for example, settle in seagrass areas as post-larvae to feed and grow. They move offshore to spawn, presumably in deep-water reefs. Fortes, (1995) obtained similarity indices for a number of sites in the Philippines (Table 3.27). The percent similarities for fish were variable and dependent on peculiarities in coastal geomorphology.

Table 3.26 Biodiversity associated with seagrass beds in the South China Sea

Country	Length of coastline (km) (National/ South China Sea regions)	No. of seagrass species	No. of associated fish species	Endangered species
Cambodia	South China Sea: 435	6[1]	No data	*Dugong dugon; Chelonia mydas*
China	South China Sea: 6,888	4	8	*Dugong dugon;* 2 turtle sp
Indonesia	NAT: 54,716	12	165	3 turtle sp
Malaysia	NAT: 4,675	10	15sp 9 fam	*Dugong dugon; 4 turtle sp*
Philippines	NAT: 22,540	16	172 sp 50 fam	*Dugong dugon*; 4 turtle sp
Thailand	South China Sea: 3,219	10	67 sp 37 fam	*Dugong dugon; turtle sp*
Viet Nam	South China Sea: 3,260	14	No data	*Dugong dugon; 1 turtle sp; 2 fish sp*
ASEAN LCR Study		20	**318 sp, 51 fam**	5 turtle sp
WORLD		**50**		**7 turtle sp**

Sources: Fortes, 1995, Fortes, 1994, Sudara *et al*., 1994, National TDA Reports, [1] Kirkman, EAS/RCU pers.comm.

Table 3.27 Shared biodiversity among mangroves, seagrasses and coral reefs (data from Fortes, 1995)

Location	Biota	Seagrass-Mangrove % similarity	Seagrass-coral reef % similarity	Mangrove-coral reef % similarity
Calancan Bay, Philippines	Fish	44.4%	13.3%	
Calatagan, Philippines	Algal epiphytes	31.4%	56.2%	11.0%
All study areas in Philippines	fish	13.0%	46.3%	

Loss of fisheries productivity. The transboundary nature of the decline in fisheries productivity in seagrass areas lies in the possible connections between fringing and oceanic reefs and among fringing reefs downstream of reversing monsoonal longshore currents. The nursery and feeding roles of seagrass beds underscore their importance in maintaining the high biodiversity and high fisheries production.

There is little quantitative data to support the level of fisheries production in seagrass beds alone (McManus *et al*., 1992) (Table 3.28). Population studies of dominant seagrass–based fish like siganids indicate their significant contribution to nearshore production, and more importantly, to the nutrition of coastal communities. More realistically, the production estimates made for coral reef fisheries should be considered as having very significant inputs from seagrasses, especially for the herbivorous species. In the Bolinao reef system of northern Philippines, siganids contribute 5 tons/km^2/year or 40% of the reef-flat fisheries (McManus *et al*., 1992). However, siganids showed a significant decrease in mean size at first reproduction to as small as 3 cm, an unequivocal sign of selection pressure imposed by overharvest. Considering that siganid fishes dominate most seagrass beds in the region, their production can be used as an index for comparing the relative health of the beds, and the extent to which these are exploited.

Table 3.28 Seagrass-based fisheries in Southeast Asia

Country	Fisheries
Cambodia	No data
China	No data
Indonesia	Siganids (rabbitfishes) are common across seagrass beds. Other fish include lethrinids (breams), lutjanids (snappers), serranids (groupers), latids, sphyraenids (barracudas), mugils (mullets), and mullids (goatfishes).
Malaysia	Serranids, theraponids, siganids, leiognathids (slipmouths), and lethrinids are commonly caught.
Philippines	Siganids (both juveniles and adults) make up 1.23% of total marine fisheries; Siganids make up 40% of reef flat fish production of 12 t/km^2/yr in Bolinao. Harvest of shells for ornamental products using rake-like gear can have negative impacts on seagrass beds.
Thailand	Juvenile groupers and snappers; prawns and *Acetes* commercially harvested.
Viet Nam	No data
ASEAN-LCR sites	• Based on frequency: Apogonids (cardinal fish) > Gobiids (gobies) > Siganids (rabbit fish); Based on commercial importance: Siganids • Four commercially important prawn species • Two crab species exploited for food

Sources: McManus *et al*., 1992, Poovachiranon *et al*., 1994, Tomascik *et al*., 1997, National TDA Reports.

Seahorse trade. Seahorses are used in Chinese medicine. The luxury trade, if left unchecked can easily lead to the demise of populations (Vincent, 1994) (Table 3.29). All participating countries except Cambodia are suppliers of seahorses, which are imported by countries where affluent Chinese communities make up a significant portion of the population. Seahorses in Southeast Asia have not made it to the CITES endangered list largely because of the scanty information on population sizes, and minimal information on the trade itself. Because they are small and slow, they are extremely vulnerable to mass harvest. Annual imports are in millions of organisms, valued at USD 55-180 per kilo dry weight, this incentive is too large for a realistic total ban. Recent studies by Vincent on pilot grow-out of seahorses with local communities in Bohol, Philippines recommend sustainable harvest practices in order to make the trade less destructive. One such step is the maintenance of pregnant individuals in holding pens until they have given birth, thus ensuring replacement of harvested individuals. Vincent, (1994) further notes that the progress in the culture of some species, living in seagrass, made in Nha Trang Oceanographic Institute in Viet Nam, may help ease the pressure on the wild populations.

Table 3.29 Salient features of the seahorse trade (data from Vincent, 1994)

EXPORTERS: China, Indonesia, Malaysia, Philippines, Singapore, Thailand, Viet Nam in Southeast Asia. Others include Australia, Belize, Brazil, Kuwait, Mexico, Pakistan, Spain, Tanzania, the United Arab Emirates, and the US.
IMPORTERS: China, Taiwan of China, Hong Kong, Singapore, Japan, Malaysia, South Korea, US.
USES: Chinese medicine for asthma, arteriosclerosis, impotence, incontinence, etc.; aquarium exhibits and for food
PRICE: USD 55 to 180 per kg of dried sea horses
ESTIMATED POPULATION SIZE: Unknown, approx 35 species worldwide
ESTIMATED GLOBAL TRADE: 20 million seahorses per year • 20 tons or 6 million animals were consumed by China in 1992. • Taiwan of China imported 3 million dried animals in 1993. • The US bought 200,000 dried seahorses from the Philippines alone in 1987, perhaps for sale in Chinatowns.

3.2 Overexploitation of living aquatic resources

3.2.1 Status of inland capture fisheries and culture production

Table 3.30 summarizes data contained in the TDA national reports of the seven participating countries. Viet Nam leads in capture fisheries production with Thailand and Indonesia-South China Sea subregions as a far second and third, resp. All together the seven countries account for 13% of global freshwater production. Freshwater aquaculture accounts for 1/5 of global production and provides fisheries 3.3 times more than that of its capture-based counterpart. Total inland aquaculture production and capture fisheries, by the 7 countries, accounts for 18% of the world total.

The economic imperatives for pursuing freshwater aquaculture are obvious. However, its growth should be pursued with policies cognizant of natural carrying capacities of freshwater systems to support production even with artificial subsidies in the form of feeds, chemicals and aeration, among others. Artificial subsidies degrade habitat quality and consequently erode the capacities of natural systems to assimilate pollutants, mineralize organics, and distribute sediments within hydrodynamic regimes. If aquaculture is to be sustained, anthropogenic inputs must be applied to maintain the health of the overall system, and not to simply increase production, which will prove to be short-lived. Afterall, the basis for aquaculture to enhance production lies in having a healthy natural system to begin with. The cost of degraded habitats is basically dissipated long-term resource rents.

Table 3.32 indicates the level of exploitation for capture marine and freshwater fisheries and the potential for expansion in aquaculture in inland waters. The qualitative determination is based on the observed level of degradation of freshwater habitats such as declining water quality, diminishing catches or culture production, and loss of biodiversity (see discussion on natural wetlands). For China, Indonesia and the Philippines, the extent of exploitation has reached full or overexploited levels. Habitat degradation has reached unsustainable levels, threatening even the safety of public health with the consumption of cultured organisms, such as when toxic algal blooms occur. Other countries have moderate scope to expand their capture and culture fisheries because habitats have remained fairly healthy. Cambodia, Viet Nam and Thailand may do so but must proceed very cautiously even in the light of economic and demographic needs.

Table 3.30 Inland capture and production in seven participating countries

Country	Capture Fisheries (t/yr)	Culture Production (t/yr)	Total
Cambodia	63,429	8,779	72,208
China-South China Sea	152,516	2,357,141	2,509,657
Indonesia-South China Sea	165,991	147,580	313,571
Malaysia	No data	No data	No data
Philippines-South China Sea	30,401	51,848	82,249
Thailand	168,502	No data	At least 168,500
Viet Nam	298,500	335,910	634,410
Total for 7 countries	At least 900,000	At least 3,000,000	At least 3,900,000
Total for world (1995)[1]	7,000,000	14,600,000	21,600,000
% of world production	13%	20%	18%

(National TDA Reports; [1]FAO 1997b)

3.2.2 Status of marine capture fisheries and coastal aquaculture

For capture fisheries the contribution of the TDA participating countries is only 8.2% of global marine production. Culture fisheries contribute a non-trivial 54% of the global total. The share of the South China Sea countries is 12% of global total marine production (Table 3.31). Unlike freshwater systems, capture fisheries production is twice that of coastal aquaculture, mainly because of the wide area of productive waters of the Sunda Shelf. All states seem to have exploited their fisheries to a high degree except for Cambodia and Malaysia which believe they can fiurther exploit marine waters (Table 3.32).

If the economic value of culture production could include the cost of environmental degradation brought about by this activity, a better comparison of the economic values of production by capture and by culture could be made. The enormous habitat degradation caused by coastal aquaculture (see discussion for mangrove habitats), is not accounted for. International financing institutions will always show positive returns for aquaculture, and this is justified by arguments of increasing food production and ensuring the capacities of developing nations to meet their protein nutritional requirements. This archaic reasoning must be substituted by appropriate policies to guide continued semi-intensive culture systems. Expansion in terms of increasing production of existing ponds can be pursued in Cambodia, and to a moderate extent in Malaysia-South China Sea and Viet Nam. The four other countries need to pursue reforestation and other mitigating measures seriously. The continued production of existing ponds may only be ensured by adapting more sustainable practices.

Table 3.31 Marine production in seven partipating South China Sea countries

Country	**Capture Fisheries (t/yr)**	**Culture Production (t/yr)**	**Total**
Cambodia	30,500	1,500	32,000
China-South China Sea	2,689,000	3,303,500	5,992,500
Indonesia-South China Sea	1,956,513	136,661	2,093,174
Malaysia	569,058	No data	At least 570,000
Philippines-South China Sea	120,592	At least 109	At least 120,700
Thailand[1, 2]	At least 768,650 (for 23 major species)	234,000	At least 1,003,000
Viet Nam	737,150	No data	At least 740,000
Total for 7 countries	6,871,463	3,604,465	10,475,928
Total for world (1995)[3]	84,000,000	6,700,000	90,700,000
% of world production	8.2%	54%	12%

[1]Potaros, 1995; [2] Siri Tookwinas & Dhana Yingcharoen, 1998; [3]FAO 1997b; All other data from TDA National Reports

Table 3.32 Degree of exploitation in capture fisheries and the potential for expansion in culture production (qualitative data from TDA national reports)

Country	**Degree of exploitation of capture fisheries (Low, Moderate, High)**		**Potential for expansion of culture production (Low, Moderate, High)**	
	Marine	**Inland**	**Marine**	**Inland**
Cambodia	Low	Moderate	High	Moderate
China-South China Sea	High	High	Low	Low
Indonesia-South China Sea	High	High	Low	Low
Malaysia-South China Sea	Moderate	No data	Moderate	No data
Philippines-South China Sea	High	High	Low	Low
Thailand	High	Moderate	Low	Moderate
Viet Nam	High	Moderate	Moderate	Moderate

3.2.3 Status of the capture fisheries potential in the South China Sea

Maximum sustainable yield (MSY) estimates are difficult to determine and there are inherent limitations in estimating them (Hillborn and Walters, 1992). Country-based MSYs are even less credible in that the range of fish stocks is never coincident with territorial boundaries. To constrain these uncertainties, estimations at basin level are made to better approximate production potentials. Table 3.33 indicates the habitat and bathymetric subdivisions of the South China Sea that were used by Pauly and Christensen, (1993) to estimate the potential catch from the South China Sea basin. At the level of subdivisions, they showed that coral reefs 10 to 50 m are fully exploited. Shallow waters with some scope for increased production are those located along the Viet Nam/Chinese and Bornean shelves. They may have actually been realized by now. The MSYs for the rest of the shallow habitats could not be estimated, but other indicators show they are fully or over-exploited. On the whole, an additional 841,000 t/yr can be had from the South China Sea if it is possible to tap the production of the deep shelf and the open ocean by exploiting large pelagics and cephalods (Pauly and Christensen, 1993).

Yanagawa, (1997) presents another South China Sea basin-wide estimate, this time with a focus on small pelagics, which can comprise shared and straddling stocks among the littoral states (Table 3.34). His study covers the period from 1978 to 1993, during which peak years are identified. He notes that after 1987, most of the 12 small pelagic fisheries reached full levels of exploitation. Furthermore, the rapid increase from 1976 to 1983 was accompanied by alternation of major species, again indicative of massive fishing selection pressure.

Thus, at the basin level, these two studies indicate that most of the conventional small pelagic species comprising the South China Sea capture fisheries, are already fully exploited. On a habitat division basis, only a few sections of the shelf can sustain further expansion. The deepwater catch may have greater scope to sustain higher fishing pressures, but economics and technology may prove to be the major constraints in catching at great depths.

Table 3.33 Fisheries potential of the South China Sea (modified after Pauly and Christensen, 1993)

Subdivision	Area (10^3 km^2)	Primary Production (t km^{-2} yr^{-1})	Potential catch 10^3 t yr^{-1}	Actual catch 10^3 t yr^{-1}
Shallow areas to 10 m	172	3,650	No estimate but fully exploited	1,046
Reef flats and seagrasses to 10 m	21	4,023	No estimate but fully exploited	275
Gulf of Thailand to 50 m	133	3,650	No estimate but fully exploited	1,242
Viet Nam and China shelf to 50 m	280	3,003	1,860	453
Northwest Phil to 10 m	28	913	No estimate	315
Bornean shelf to 10 m	144	913	257	105
Southwest shelf to 10 m	112	2,433	No estimate but fully exploited	962
Coral reefs, 10-50 m	77	2,766	295	291
Deep shelf 50-200m	928	730	1,688	176
Open ocean 200-4000 m	1,605	400	1,686	80
Total South China Sea	**3,500**	**Mean = 1,143**		**4,945**

Table 3.34 Small pelagic fisheries in the South China Sea, 1978-1993 (Yanagawa, 1997)

Group	Peak landings (mt)	Peak year
Round scads	596,000	1991
Selar scads	229,000	1990
Jacks, cavalla and trevallies	147,000	1993
Indian mackerel	357,000	1992
Indo-Pacific mackerel	212,000	1993
Spanish mackerel	114,000	1993
Kawakawa	283,000	1992
Frigate and bullet tunas	128,000	1992
Sardines	716,000	1993
Anchovies	419,000	1993

3.2.4 Status of large pelagics: the case of tunas

Because large pelagics including tunas and perhaps sharks, are highly migratory, the global ocean, not the basin scale, is most appropriate in analyzing their state of exploitation. Four South China Sea nations are among the top ten leading tuna fishing nations of the world. The combined catch of Taiwan of China, Indonesia, the Philippines and Thailand consistently made up 23% of the global landed catch over a six-year period from 1988 to 1993. Peckham, (1995) notes that the catch of the South China Sea countries at 725,200 t and of the world at slightly over 3 million tons, has stabilized, and may indicate full state of exploitation (Table 3.35). An analysis of the trade in tuna and tuna products is discussed in 3.2.6.

Table 3.35 World production of principal tuna species by principal fishing nations, 1988-1993 (10^3 mt) (data from Peckham, 1995)

Country	1988	1989	1990	1991	1992	1993
Japan	753.2	673.1	653.9	717.1	669.1	776.6
Taiwan of China	220.4	256.7	308.1	230.4	332.2	282.0
Spain	242.4	250.3	263.1	265.8	253.5	255.0
Republic of Korea	147.1	170.9	232.7	266.5	224.6	241.0
United States	276.0	245.2	232.6	235.6	261.3	221.3
Indonesia	170.5	180.1	202.8	211.1	216.3	216.0
France	152.9	142.1	152.7	168.8	234.3	158.5
Philippines	113.0	126.8	180.8	198.0	176.0	148.5
Mexico	132.8	136.9	125.7	129.0	131.5	118.5
Thailand	92.9	82.1	102.4	84.8	74.5	78.7
Total for South China Sea countries	**596.8**	**645.7**	**794.1**	**724.3**	**799.0**	**725.2**
Global total	**2,847.9**	**2,853.0**	**3,071.1**	**3,144.8**	**3,167.9**	**3,202.00**
South China Sea contribution to Global Total	**21%**	**23%**	**26%**	**23%**	**25%**	**23%**

3.2.5 Immediate causes of overexploitation by country

Many factors cause unsustainable levels of fishing pressure, especially in the nearshore. Destructive fishing practices, bycatch, post-harvest losses, siltation and habitat destruction are among the major ones (Table 3.36) (Silvestre and Pauly, 1997). Region-wide, the issues of overexploitation are common, with perhaps qualitative differences for Cambodia which has emerged from civil strife, and for Viet Nam which has just entered the free market economy. Nonetheless, demographic and development pressures seem to be the common socio-economic drivers in the overharvest of aquatic resources.

Table 3.36 Immediate causes of overexploited coastal fisheries in participating South China Sea countries (modified after Silvestre and Pauly, 1997; National TDA Reports)

Key issues	Cam	Chi	Ind	Mal	Phil	Tha	Viet
1. Overfishing	✓	✓	✓	✓	✓	✓	✓
2. Inappropriate exploitation patterns	✓		✓	✓	✓	✓	✓
3. Destructive fishing practices	✓	✓	✓	✓	✓	✓	✓
4. Small and large scale fisheries conflicts	✓			✓	✓		✓
5. Losses due to bycatch		✓	✓	✓	✓	✓	✓
6. Post-harvest losses	✓	✓	✓	✓	✓	✓	✓
7. Siltation	✓	✓	✓	✓	✓		✓
8. Habitat destruction	✓	✓	✓	✓	✓	✓	✓
9. Reduced biodiversity	✓		✓	✓	✓	✓	✓
10. Land-based pollution	✓	✓	✓	✓	✓	✓	✓
11. Oil spills			✓	✓	✓	✓	✓

3.2.6 Transboundary issues associated with overexploitation

A significant number of the causes and impacts of overharvesting of living aquatic resources is transboundary in nature (Table 3.37). Although the information base to show these transboundary features is poor, there are significant indicators that can be used to identify and highlight them. The loss of biodiversity in marine habitats was discussed in previous sections. The presumably fully exploited states of small pelagics and tunas have also been shown retrospectively with catches reaching stable peaks, followed by a change in species composition of the fishery (Yanagawa, 1997, Peckham, 1995). The subsequent analysis will therefore deal mainly with bycatch, food security and fishery trade.

High bycatch of commercial operations. FAO, (1997a) discussed the sources of wastage in fisheries. Many terms have been used to describe wastage and the matrix below is drawn to clarify their meanings. In general, wastage is composed of discards at sea and post-harvest losses. Thus, damaged target species and bycatch make up discards. Moreover, the classification of target vs. non-target species is highly variable with species being classified as one or the other, depending on preferences and seasonality of market demands.

TOTAL CATCH	GEAR SELECTIVITY	
	Target species or group	Non-target species or group
Discarded catch (thrown	Damaged, small size, of	Bycatch – Amounts not

away at sea; amounts not recorded nor reported)	inferior quality; disposed of to meet quota limits – Amounts not recorded nor reported	recorded nor reported
Retained catch (portion that gets landed and recorded)	Desired species or group; retained juveniles = trash fish	Incidental catch including juveniles = trash fish

Discarded bycatch comprises perhaps the most significant source of wastage in the global fisheries. FAO, (1997b) notes that if a small number of mature specimens from a healthy stock make up the bycatch, the incurred fishing mortality may cause relatively small damage. However, when the bycatch consists of many juveniles of commercially exploited stocks, the impact on the viability of populations or stocks may be severe. Commercial operations (trawling, seining, bagnetting, etc.) are perhaps the biggest source of bycatch wastage. By virtue of the efficiency of gear capture and the wide area of operations, commercial fleets make up monopolies of the sea, with a singular contribution to overexploitation. In many cases, their aggregate fishing pressure far exceeds that exerted by subsistence fishers, who are often blamed for overharvest.

FAO, (1994 in FAO, 1997b) estimated that discarding of bycatch amounted to an average of 27 million tons per year, or approximately 32% of the global annual production of marine capture fisheries. The issue is not only transboundary but of a global significance as well, especially when the catch potential of the world's oceans seems to have been reached. Assuming that this percentage is a conservative estimate for South China Sea states, this translates to 2.2 million tons/year of current (and future) fish that is lost.

Bycatch cannot be totally eliminated for biological, technological, economic and legal reasons (FAO, 1997a). However, the magnitude it has reached poses imminent danger to fish stocks and to food security. Karnicki, (1995) notes that in order to maintain 1993 world annual fish consumption rate of 13 kg/person in the year 2010, the amount of fish for direct human consumption should be increased from 72.3 to 91 million t/year. To achieve this, considering that marine stocks are fully or over exploited, he suggests three approaches. First is to reduce waste, and to use bycatch; second, increase consumption of small pelagics, and third: use unconventional species like krill.

The issue of bycatch in particular, and the need for responsible fisheries, in general, is covered by a number of international initiatives (FAO, 1997b). All drawn in 1995, they include the Rome Consensus on World Fisheries, Article 7 of the Code of Conduct on Responsible Fisheries, and the Kyoto Declaration and Plan of Action on the Sustainable Contribution of Fisheries to Food Security. They provide the broad context of global collaboration needed to implement sustainable fishing practices. The UNCLOS Agreement for the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stock focuses on stocks that are exploited within national territories as well as in the high seas. The mix of jurisdictions demands international collaboration if the bottom line is to sustain such populations. All these initiatives apply to the South China Sea, taking into account the biological state of the resources and the development goals of the littoral states.

Table 3.37 Transboundary issues on overexploitation

Transboundary issues And quality of information	Cam	Chi	Ind	Mal	Phil	Tha	Viet
Inland fisheries							
Loss of biodiversity in the Mekong River Basin, including endemic species, and migratory organisms, a number of which are considered endangered – **Poor**	✓	✓				✓	✓
Marine fisheries							
Loss of biodiversity among shared stocks and genetic resources – **Poor**	✓	✓	✓	✓	✓	✓	✓
Fully exploited production of shared and migratory stocks (small and big pelagics) – **Poor**	✓	✓	✓	✓	✓	✓	✓
High bycatch by commercial operations – **Poor**		✓	✓	✓	✓	✓	✓
Loss of breeding grounds, and recruitment and spawning areas – **Poor**	✓	✓	✓	✓	✓	✓	✓
Regional food security in ability to meet protein nutritional requirements **– Fair**	✓	✓	✓	✓	✓	✓	✓
Fishery trade of overexploited and endangered stocks **– Poor**	✓	✓	✓	✓	✓	✓	✓
Foreign poaching - **Poor**	✓		✓	✓	✓	✓	✓

Regional food security. FAO defines food security as "physical and economic access, by all people at all times, to the basic food they need (cited in Williams 1996). A fundamental question is whether the South China Sea countries, richly endowed with aquatic resources, are secure in accessing this wealth for food. Table 3.38 summarizes parameters used in this analysis to determine population pressure on fish production, and the role trade should take in achieving the seemingly diametrically opposed goals of revenue generation and food security. To maintain current patterns of fish consumption in the year 2005, Cambodia, Philippines and Viet Nam will require more fish more than they produced in 1994 assuming that 100% of the catch in these three countries will be available for domestic consumption. If Cambodia and Viet Nam wish to reach the nutritional minimum requirement of 21.5 kg/person/year in 2005 (assuming 50% dependence on fish for animal protein) they need to dramatically increase food production; Cambodia by 270% of its production in 1994, and Viet Nam by 163%. Indonesia may have enough, but the population distribution is so heterogeneous and transport infrastructure so poor that there will be severe shortages in overpopulated areas but sufficient supplies in less crowded ones. Thailand and Malaysia have successfully reduced population growth rates, so that domestic demands need not be sacrificed for export revenues.

Currently, South China Sea countries are net exporters, and will most likely remain so assuming no drastic reductions in fish production. Regionally, total population by 2005 will reach 503 million using current growth rates. For all to reach the minimum nutritional requirement, about 86% of current production will be consumed domestically for food. This implies that the region can export 14%, at most. If export levels are to increase beyond 14%, either domestic consumption will fall below the minimum requirement, total fish production will have to be increased, or population growth rate will have to be reduced. Reductions in harvest wastage will also be a strategic measure. The options may be difficult to optimize toward one goal or the other, but a compromise towards long-term benefits for society, the ecology and the economy will have to be formed now.

The South China Sea countries will have to define their priorities within an evolving context of trade globalization and the eventual removal of tariff barriers as defined by usually inequitable trade agreements. Whether or not these include the domestic demands of a growing population and the protection of their extremely vulnerable living resource base, is a most crucial decision to be made now.

Table 3.38 Fish requirements in selected South China Sea countries for the year 2005 (data as cited by Silvestre and Pauly, 1997, 1998 World Almanac)

Country	**Populatio n1996 (10^6)**	**Finite growth rate (%)**	**Population 2005 (10^6)**	**Fish consumptio n (kg/p/y)**	**Total fish produced, 1994 (10^3 t/y)**	**Total fish required for food in 2005 (10^3 t/y)**
Cambodia	10.2	2.7	13.0	12.0	103	156
Indonesia	197.6	1.5	225.9	15.5	4,060	3,502
Malaysia	20.6	2.0	24.6	29.5	1,173	726
Philippines	69.3	2.2	84.3	36.1	2,657	3,043
Thailand	61.4	1.0	67.2	25.3	3,432	1,699
Viet Nam	76.3	1.6	88.0	13.4	1,155	1,179

Fishery trade. Tables 3.39 and 3.40 give an overview of the value of the share of South China Sea countries (no data for Cambodia and Viet Nam) in the world fishery trade. Exports coming from six South China Sea countries accounted for an average of 11% of world exports yearly for the period 1988-1992. Their share of imports was only 4% of the yearly global value. Thus, the region is a net exporter of fishery products with a net trade surplus of USD 3.5 billion posted in 1992. The more affluent states of Brunei and Singapore were net importers, while the rest were net exporters, notably Thailand whose export earnings was 3.3 times that of imports.

The consumption rates of fish per capita per year (Table 3.38) shows that the Philippines, Malaysia and Thailand are above the minimum requirement of 21.5%. Indonesia, Viet Nam and Cambodia have still to reach this. Average consumption rates only apply if fish are available. For food security, further analysis will have to be made if South China Sea countries are serious in meeting nutritional needs for all. How trade impinges on fish availability becomes a significant question before meaningful macroeconomic policies can be formed at the national and regional levels.

Table 3.39 Share of selected South China Sea countries in world exports of fishery products, in USD 1,000 (data from Ferdouse, 1994)

Country	1988	1989	1990	1991	1992
Indonesia	664,483	767,422	983,571	1,192,082	1,178,552
Malaysia	191,242	210,140	229,514	264,938	302,576
Philippines	407,504	409,879	395,960	467,729	393,997
Thailand	1,630,891	1,959,428	2,264,937	2,901,366	3,071,780
Brunei	300	350	380	440	400
Singapore	356,193	359,071	414,810	499,950	494,128
Total for 6 South China Sea countries	**3,250,613**	**3,706,290**	**4,289,172**	**5,326,505**	**5,441,433**
Global total	**31,804,116**	**35,886,233**	**39,539,969**	**43,546,408**	**45,451,914**
% of Global total	**10**	**10**	**11**	**12**	**12**

Table 3.40 Share of selected South China Sea countries in world imports of fishery products, in USD 1,000 (data from Ferdouse, 1994)

Country	1988	1989	1990	1991	1992
Indonesia	19,376	30,850	42,777	47,395	56,145
Malaysia	143,508	164,552	145,831	170,478	244,789
Philippines	63,063	65,730	84,809	96,109	111,000
Thailand	537,918	726,846	794,423	1,049,962	942,092
Brunei	7,404	7,180	7,160	6,780	7,000
Singapore	370,311	366,126	361,582	460,545	543,769
Total for 6 South China Sea countries	**1,141,580**	**1,361,284**	**1,436,582**	**1,831,269**	**1,904,795**
Global total	**35,269,622**	**35,886,233**	**39,539,969**	**43,546,408**	**45,451,914**
% of Global total	**3**	**4**	**4**	**4**	**4**

The tuna trade. The status of tuna on a global scale was discussed earlier and the fisheries have probably reached a stable state of full exploitation. The role South China Sea countries play in this trade is of utmost importance. Table 3.41 highlights the fact that three South China Sea countries (Thailand, Philippines and Indonesia) were responsible for an average of 72% of the world tuna export market during the period 1990 to 1993. Using data on canned tuna production in these countries, export accounts for 91 to 96% of total production (Table 3.42). In contrast, Japan exports only 3-5% of what it produces. Spain and Portugal sell about 16 and 30 % of their production, respectively. The US does not export its canned tuna. Japan, Western Europe, and the US, used 83 to 90% of their tuna products for their domestic needs (Table 3.43).

These trading patterns indicate that affluent countries are net importers and that low-income food-deficit countries become net exporters as fish becomes a scarce commodity. These patterns evolve in response to profit being the major market force, and where agri-based economies have to exchange natural capital for hard cash.

Table 3.41 Exports of canned tuna, 1990-1993
(1000 standard cases, at 48 cans/case) (Peckham, 1995)

Country	1990	1991	1992	1993
Thailand	26,340	30,843	27,529	29,223
Philippines	4,944	4,853	5,220	6,067
Ivory Coast	4,421	5,368	4,432	5,636
Indonesia	2,098	4,642	2,150	2,818
Senegal	1,815	2,055	1,816	2,363
Spain	1,258	1,846	1,673	2,200
Ecuador	188	471	868	2,044
France	668	674	675	1,060
Malagasy	-	-	-	992
Seychelles	447	703	620	670
Italy	464	480	388	620
Maldives	528	561	558	581
Portugal	410	683	580	440
Venezuela	106	282	87	432
Japan	433	518	340	390
Total-South China Sea countries	**33,382**	**40,338**	**34,899**	**38,118**
Global total	**44,420**	**54,479**	**47,336**	**56,036**
Contribution of South China Sea countries to Global total	**75%**	**74%**	**74%**	**68%**

Table 3.42 Percentage of production exported by leading producers of canned tuna, 1990 to 1993 (data after Peckham, 1995)

Country	1990	1991	1992	1993
US	0	0	0	0
Thailand	100	98	93	95
Spain	13	16	18	24
Japan	4	5	3	4
Philippines	97	99	100	96
Mexico	0	0	0	0
Indonesia	64	91	86	91
Senegal	91	98	96	94
Portugal	24	31	32	21
Iran	0	0	0	0
Ecuador	12	34	54	100

Table 3.43 Comparison of domestic use and catch by principal markets, 1990-93
(10^3 mt) (Peckham, 1995)

Market	1990	1991	1992	1993
Japan	834	883	867	1,014
Western Europe	686	803	805	812
United States	710	794	760	642
Other	309	338	353	334
Total Usage	**2,539**	**2,818**	**2,785**	**2,802**
Total Catch	**3,071**	**3,145**	**3,168**	**3,202**
% Used for domestic consumption	**83%**	**90%**	**88%**	**88%**

The trade of sharks and shark fisheries products. The biology of sharks is not well known and they may migrate throughout the South China Sea. They are also caught as bycatch by gear targetting tuna and swordfish, among others. Currently, the demand for shark products is running high for their medicinal, exotic food, and ornamental uses (TRAFFIC 1996). The trade in Southeast Asia is particularly interesting. Thailand started its shark fisheries in 1947 and Malaysia, 14 years later. Philippines and Indonesia began in the early '70s. To date, Indonesia leads the four South China Sea countries based on landed catch (Table 3.44). In terms of biodiversity, at least 27 species are landed in the Philippines, 17 in Thailand, and 6 in Malaysia. The faunistic overlap between Thailand and the Philippines is minimal, and between these two countries, a total of 42 species has been recorded, with only three species common to both (Table 3.45). No species list was available for Indonesia but it could very well exceed the number recorded for the Philippines.

Table 3.44 Commercial elasmobranch fisheries in South China Sea countries (1950-1991) (10^3 mt) (modified after TRAFFIC 1996)

Country	1950	1960	1970	1980	1985	1991
Thailand	2	4.3	22.4	9.5	9.2	11.8
Malaysia	-	3.2 (1961)	3.6	10.9	10.3	16.9
Indonesia	-	-	10.3 (1971)	42.9	54.3	79.8
Philippines			6.9	9.7	10.9	19

Table 3.45 Shark and ray species landed in South China Sea countries (data from TRAFFIC 1996)

Country	Philippines	Thailand	Malaysia
Aetoplatea zonura	✓		
Alopias vulpinus	✓		
Atelomycterus marmoratus	✓		
Carcharhinus amblyrhynchoides		✓	
C. amblyrhynchos	✓	✓	
C. amboinensis		✓	
C. brevipinna		✓	
C. dussumieri		✓	
C. leucas		✓	
C. limbatus		✓	
C. melanopterus	✓	✓	
C. sorrah		✓	
Centrophorus spp	✓		
Centroscyllium cf. kamoharai	✓		
Chiloscyllium griseum		✓	
C. indicum		✓	✓
C. punctatum		✓	
Dasyatis sp.			✓
Dasyatis kuhlii	✓		
Galeocerdo cuvier	✓		
Gymnura sp			✓
Hemitriakis leucoperiptera	✓		

Continued Table 3.45

Country	Philippines	Thailand	Malaysia
Hexanchus griseus	✓		

Hexatrygon sp.	✓		
Himantura uarnak	✓		
Himantura undulata	✓		
Isurus oxyrinchus	✓		
Mustelus cf. griseus	✓		
Nebrius ferrugineus	✓		
Pristis cuspidatus	✓		
Rhyncobatis djiddensis			✓
Rhincodon typus	✓		
Rhinobatidae	✓		
Rhizoprinodon acutus		✓	
R. oligolinx		✓	
Scoliodon laticaudus		✓	
S. sorrakawa			✓
Scyliorhinus tprazame	✓		
Sphyrna sp.	✓		✓
S. lewini		✓	
S. mokarran	✓	✓	
S. zygaena	✓		
Squalus acanthias	✓		
S. cf. rancureli	✓		
Taeniura lymma	✓		
Triaenodon obesus	✓		
Total	**27**	**17**	**6**

Table 3.46 indicates the major markets for Philippine exports on sharkfins and shark liver oil and compounds. Hong Kong, Japan, Korea and Singapore bought the most shark fins, evidently for shark fin soups. Japan was the major market for shark liver oil and compounds.

Thailand shows a clever trading strategy in importing cheap raw materials and re-exporting value added shark goods with 265 to 385% markup in price per kg (Table 3.47). In 1994, it imported, mainly from Canada, Hong Kong and Japan, shark products weighing 130,000 kg costing 10 million USD. It exported only 27% of this weight but sold it at 10.5 million USD. Major markets in 1994 included Hongkong and Japan. The trading pattern changed dramatically from 1993 to 1994. In 1993, Thailand imported 80% of the total volume of its raw materials from Asia, but exported only 28% of its products to markets in this region. In 1994, Asia accounted for 60% of both exports from and imports into Thailand.

Traditionally, shark meat is consumed domestically. The more exotic shark products, such as those used for producing squalene oil, command lucrative prices and hence, the economic push to hunt for more. Because of the high uncertainties involved in determining exploitable elasmobranch biomass, it might be prudent to limit catches for the production of high value products. The supply of shark meat for domestic consumption must also be managed appropriately. More than economic tradeoffs will have to be considered in the use of living resources whose renewal rates are finite, and when food security is at stake.

Table 3.46 Philippine exports of shark fins, shark liver oil and non-modified chemical fractions, 1993-1994 (data from TRAFFIC 1996):

Importer	Shark fins				Shark liver oil and compounds			
	1993		1994		1993		1994	
	Quantity (net kg)	Value FOB$	Quantity (net kg)	Value FOB$	Quantity (net kg)	Value FOB$	Quantity (net kg)	Value FOB$
Australia			20	200				
Brunei	698	5,214	478	5,974				
China Mainland			350	3,500				
Hong Kong	30,837	295,464	9,478	92,097				
Japan	461	17,854			97,349	806,070	26,875	207,228
Korea	500	9,760	1,800	52,380	39,017	39,017	14,400	148,104
Singapore	186	1,860	481	8,502				
Taiwan of China					190	1,000		
Total	**32,682**	**330,152**	**12,607**	**162,653**	**136,556**	**846,087**	**41,275**	**355,332**
Average Price $/kg		**10.10**		**12.90**		**6.20**		**8.61**

Table 3.47 Thailand shark fin trade, exports and imports in 1994 (data from TRAFFIC 1996)

Trading Partner	Exports out of Thailand				Imports into Thailand			
	1993		1994		1993		1994	
	Quantity (kg)	Value (Baht)	Quantity (kg)	Value (Baht)	Quantity (kg)	Value (Baht)	Quantity (kg)	Value (Baht)
Austria	13	43,652						
Australia	17	20,373						
Brunei			2	10,070				
Canada	9	4,550	5	3,198	1,918	2,317,068	26,890	14,565,421
China (Main)					2,311	2,116,682		
Chile	3	10,650						
Denmark					742	132,707		
Hong Kong	5,491	1,601,778	12,569	11,741,410	19,218	7,036,461	26,768	7,968,417
India					15,713	6,469,721		
Indonesia					12,048	4,170,578	13,795	3,755,571
Japan	661	1,181,598	6,642	5,604,932	28,390	7,568,445	38,213	6,570,914
Malaysia			2	10,070				
Myanmar			432	67,560				
Norway					3,471	1,592,460	2,240	1,357,343
US					3,073	861,328		
Viet Nam					2,146	516,666	250	60,401
Trade with Asia	**28%**	**13%**	**57%**	**41%**	**80%**	**78%**	**62%**	**46%**
Total trade	**21,856**	**20,796,459**	**34,538**	**42,175,190**	**99,750**	**35,857,793**	**127,442**	**40,338,131**
Average Price B/kg		**952**		**1,221**		**359**		**317**

Making fisheries trade responsible. Market forces have been righty blamed for overfishing, over-investment, and the consequent collapse of commercial fish stocks. They shaped the over-all development of the world fisheries (Karnicki, 1995) such that 30% of total production was traded at USD 3 billion in 1980 to USD 40 billion in 1993. In Southeast Asia, the littoral states became the leaders in shrimp culture production.

Such market forces also identify where subsidies should be infused such as in the build up of fishing fleets, the development of highly efficient fishing gear and price support, all of which led to serious economic losses through the backlash of adverse environmental impacts. Thus, the economic regimes, within which fisheries at its currently vulnerable stage can be sustained, will have to be totally redefined. Such regimes must take into account long-term ecological parameters such as renewable rates and carrying capacities, and the quality of life of domestic consumers, as the bases for economic incentives to conserve living aquatic resources.

Tietze (1995) suggests the mobilization of fisheries credit for domestic marketing in Asia and the Pacific as an approach to maximize the social and economic benefits from the fisheries. Nutritional requirements including those of marginal sectors, dependence on fish protein, traditional groups involved in markets and distribution, and the associated institutional and regulatory frameworks, are among the major social and institutional factors to be considered. Tietze notes that given limited fish supplies, a growing demand, and trade globalization, fish marketing and processing in Asia will tend towards regionalization and commercialization. Such will not necessarily lead to a decrease in the market share of domestic consumption because of:

(1) increasing purchasing power in the region,
(2) new market opportunities for value-added products,
(3) scope for processing under-utilized species, and
(4) the external supplies of raw materials with trade liberalization.

Given this broad context, the scale of credit mobilization is critical. Small-scale trade facilities reach the marginalized sectors, and the medium- to large-scale operations provide for market infrastructure needed to promote domestic trading at wider scales.

The macro and microeconomic instruments to support domestic fish markets, while protecting the living resource base, must take into account the fundamental shift in focus from profit (export markets) to domestic food security. At the regional level, the trade of shared stocks, migratory species and straddling stocks must be based on the precautionary principle where information uncertainties cannot provide for MSY estimates, but where best science can help set quota limits.

3.3 Pollution of aquatic environments

3.3.1 Overview of ranked sources of pollution

Table 3.48 summarizes the sources of pollution of the participating countries in the South China Sea, the quality of the database, and the perceived contribution of these sources to the state of aquatic environments in each country. Wastes from domestic, agricultural, and industrial sources, along with sediments and solid wastes are the major sources of pollutants that impinge on both freshwater and coastal systems in the seven countries. Land-based sources play a major role in both inland and coastal pollution. Ship-based sources contribute relatively small amounts, but may have severe impacts when large volumes are released such as during major oil spills. Atmospheric inputs may seem innocuous at the present time because of a very poor database and because their impacts are harder to establish given the nature of atmospheric chemistry and the larger scales needed to carry out appropriate studies of air sheds. It must be pointed out however, that atmospheric pollutants are most potent in being transported across national boundaries. This was made evident during the extensive forest fires that occurred in Indonesia that caused smoke to shroud Malaysia and western Philippines. On a global scale, the ashfall debris injected into the stratosphere by Mt. Pinatubo's eruption caused major weather anomalies worldwide.

The density of pollution data differs from nation to nation. (See Appendix 1 for the detailed data compilation of waste production by country). Taken as a regional data set, major gaps exist and there is great need to monitor the major pollutant sources and the rates at which they release pollutants. Monitoring data is often non-existent or in some cases of such poor quality that they are better ignored than used for management decisions. Monitoring the amount of effluent dumped and its effects are essential before remediative efforts are made. Given that pollutants enter water bodies from point and diffuse sources, and interact with the substrate, suspended and dissolved load, it is difficult to attribute any impact to a pollutant or a source with unequivocal certainty. It cannot be repeated enough how important monitoring data are. They provide information on the current state of the environment, the natural variability or noise in the system, the input from anthropogenic sources and the result of mitigative effforts. The impacts are influenced by the nature of the pollutants, not in isolation of other substances and particles in the water but in their interaction with these. Hence, the management of pollution requires a holistic view of the natural and anthropogenic sources and their impacts. Appropriate mitigation can only be achieved by reducing loads across all man-made sources, and by addressing the social and economic drivers which influence these.

Table 3.48 Ranked sources of pollution among participating countries in the South China Sea[1].

Source	Rank & Data base	Contribution to pollution of national aquatic environments (L=Low, M= Moderate, H= High)						
		Ca	Ch	Indo	Mal	Phil	Tha	Viet
• Domestic waste	1-Fair	H	H	H	M	H	H	H
• Agricultural waste	2-Poor	M	H	H	M	H	H	H
• Industrial waste	2-Poor	M	H	H	H	H	H	H
• Sediments	3-Poor	M	H	H	M	H	H	H
• Solid waste	4-Fair	H	H	H	M	H	H	H
• Hydrocarbons	5-Poor	L	M	H	M	M	M	M
• Ship-based sources	6-Poor	M	M	M	M	M	M	M
• Atmospheric	7-Poor	M	M	M	M	M	M	M

[1]Ranking of pollution sources was done during the Second Meeting of National Coordinators (June 1998).

Figure 5. Biochemical oxygen demand loading from domestic sources in each sub-division in the South China Sea.

3.3.2 Domestic wastewater

The data given by the national reports were not amenable to comparisons across countries, but the raw data they provided on a subnational level was crucial in generating the regional picture for watersheds that interact with the South China Sea basin. (See Appendix 1.) To make the data comparable, subnational population growth rates were used to estimate 1996 populations at the South China Sea country level. The BOD generated by each South China Sea country was approximated using WHO daily per capita generation of 0.05 kg. Koe and Aziz, (1995) provided estimates of daily BOD removal for four countries.

About 6 million tons of BOD are generated each year by the coastal population of the 7 participating countries of the South China Sea alone (Table 3.49). Of these, only 11% is removed by sewage treatment in four countries. Assuming the same population growth rates prevail up to 2005, the generated BOD will increase to 6.6 million tonnes. If the amount removed by sewage treatment is not significantly increased from the insignificant level of 11%, the coastal waters of the Sunda Shelf from the Indo-China Peninsula to Malaysia and Indonesia, across to the western Philippine shelf, will become eutrophic.

One of the signs of a reduced assimilative capacity are the frequent incidence of toxic and non-toxic algal blooms in the region. While science still has to determine the mechanisms behind the dynamics of blooms, which occur both in polluted and pristine areas, the role of nutrients in enhancing primary production has been known since Leibig's times in the 1890's. Various species exist along a gradient of nutrient concentrations, so that some prefer low levels while others require high nutrient concentrations. The monospecific dominance that occurs during blooms may be because of optimal nutrient regimes and the concurrent hatching of cysts that may have been seeded in previous blooms and biologically disturbed sufficiently to excyst. The horizontal transport of cyst material may be possible but perhaps occur only at localized scales because of its relatively heavy density. Events like the warm phase of the El Nino-Southern Oscillation may influence the development and spread of toxic algal blooms (MacLean, 1989).

Because human populations congregate in cities, it will be most strategic to prioritize the establishment of sewage treatments in the emerging megacities of the littoral states. In the seven countries, there are 93 cities with populations over 100,000 (Table 2.2). To date, at least 30% of the population live in these crowded areas, so that waters receiving domestic waste from these cities are themselves pollution hot spots.

Table 3.49 Generation of BOD by participating South China Sea countries

Country[1]	South China Sea Population[2] (% National) (x 10^3 persons)	Population in cities (x 10^3 persons) (% of South China Sea population)	Pop growth rate (%)[3]	BOD generated (10^3 ton/yr)[4]	BOD removed by sewage treament[5] (10^3 ton/yr)
Cambodia	1,985 (18%)	1,775 (89%)	2.7	36.2	No treatment
China	59,694 (5%)	21,031 (35%)	1.6	1,089.4	<10%
Indonesia	105,217 (50%)	>50,161 (48%)	2.9	1,920.2	364
Malaysia	10,336 (51%)	1,527 (15%)	3.3	188.6	53
Philippines	23,633 (31%)	6,342 (27%)	2.1	431.3	149
Thailand	37,142 (62%)	0	1.4	677.8	89
Viet Nam	75,124 (100%)	2,144 (3%)	1.6	1,371.0	No treatment
Total	313,131 (19%)	>82,980 (>27%)	1.4	5,714.5	655 (11%)
2005	359,837			6,567.0	722 (1995 level of treatment)

[1]Only populations of subdivisions interacting with the South China Sea were included, and were recalculated to 1996 using growth rates in third column.
[2]Total population for all South China Sea subdivisions in a country was obtained.
[3]Average population growth rate for all South China Sea subdivisions in a country was obtained using a weighted mean method.
[4] Estimated BOD production using 0.05 kg/person/day (*Economopoulous* 1993)
[5] Koe and Aziz, 1995.

3.3.3 Agricultural waste

Table 3.50 Use of fertilizers and pesticides in South China Sea countries (TDA national reports)

South China Sea subregions	Rice fields (10^3 ha)	Aquaculture areas (10^3 ha)	Fertilizer use (ton/yr)	Pesticide use (ton/yr)
Cambodia	1,835	No data	>40,000	No data
China	3,425	2,476	3,636,685	>89,000
Indonesia	4,966	243	>5,600,000	28,706
Malaysia	No data	7	No data	No data
Philippines	1,236	20	181,084	No data
Thailand	8,613	No data	No data	No data
Viet Nam	1,500	No data	110,250	No data
Total			**>9,600,000**	**>>118,000**

Waste generated by agriculture and aquaculture and which enters water bodies in a diffuse mode, makes up the second most important group of pollutants in the seven countries (Second National Coordinator's Meeting) and in the region (Koe and Aziz, 1995). These include fertilizers and pesticides (fungicides, herbicides and insecticides) which are applied to enhance plant growth and production by eliminating their competitors, predators and parasites. China uses the most amount of fertilizer at 1000 kg/ha/yr and Cambodia, the least at 22 kg/ha/yr. Fertilizers when leached to aquatic environments contribute to nutrient loading in addition to that contributed by domestic sources. To evolve environmentally friendly farm practices that minimize the use of fertilisers and biocides, and to enhance soil retention of fertilisers should be the aim of efficient farmers.

Data on pesticide use is scarce, and detecting its presence in aquatic environments requires expensive methods that most government laboratories in the region cannot afford. However, it is important to determine their concentrations in waters next to intensive farming areas as they can decimate biodiversity and productivity in aquatic systems. China reports more than 89,000 tons used in its South China Sea areas in 1995. Indonesia used about 29,000 tons annually during the period 1992-1996 (Table 3.50).

The ill effects of pesticides have been established. As antibiotics, their continued use lead to resistance among target organisms making their population growth less controllable. The more insiduous effects of pesticides are on non-target organisms that are critical to ecosystem function as well as directly to man. They also have a host of adverse effects on man including carcinogenic properties. Integrated pest control programs have been implemented in a number of countries, and the use of pesticides should be reduced to minimum levels.

In the past, the sale of pesticides was not only motivated by the desire to enhance crop production by eliminating undesirable organisms in the culture system. Their use was promoted by chemical manufacturers and the International Monetary Fund through a program called the "Green Revolution" of the sixties (Agenda 21-Indonesia, 1997). Consequently, government provided subsidies to buy pesticides. Worse, the pesticides made available in the region were those that were banned in the countries where they were manufactured because of their broad spectrum effects, e.g. DDT and chlordane. Today, there is no reason or incentive to duplicate this mistake region-wide.

3.3.4 Industrial waste

Table 3.51 Industrial waste discharges from coastal and non-coastal installations

South China Sea regions-Country	BOD (t/y)	N (t/y)	P (t/y)	Heavy Metals (t/y)	Suspended solids (t/y)
Cambodia	No data	No data	No data	No data	No data
China	10,345	370	17	25.4	17,304
Indonesia	25,992	No data	No data	No data	No data
Malaysia	426.4	>1,000	No data	No data	1,369
Philippines	>49,000	No data	No data	No data	No data
Thailand	>340,000	>400	No data	No data	No data
Viet Nam	>>4,500	Data given as wastewater volume		96,560	>13,000
Total	**>430,000**	**>1,800**	**No basis**		

Considering the incomplete data base, industries release a minimum of about 430,000 tons of BOD into aquatic systems interacting with the South China Sea (Table 3.51). Eighty percent of the reported value comes from Thailand, of which 50% is conveyed by the river systems of Chao Phraya, Ta Chin, Mae Klong, and Bang Pakong.

Data provided on heavy metals are incomplete. Viet Nam whose major rivers are all transboundary, reports an annual load of at least 96,560 tons/year, 96 times more than Japan disposed of in 1988 (Table 3.52). Around 80% of this load come from the Dong Nai-Saigon River. In contrast, China reports the release of only 25 t/y. Metal specific data should bear out whether limits have already been exceeded. Viet Nam indicates in its national report that in the Northern Economic Zone, the amounts of Pb, Zn, and Cu are 7-10 times the allowable limits.

Table 3.52 Estimated disposal of toxic substances (10^6 t) (Source: State of the Environment in Asia and the Pacific, Economic and Social Commission for the Asia-Pacific, 1995 as cited in Agenda 21-Indonesia, 1997)

Country, Year disposed	Estimated production of hazardous waste (10^6 t/yr)[1]	Toxic to humans	Toxic to aquatic organisms	Toxic levels of heavy metals
Japan, 1988	0.82	13,715	15,877	1,034
China, 1987	50	3,226	4,098	155
Indonesia, 1986	5	195	247	7
Malaysia, 1987	0.4	181	217	9
Philippines, 1987	0.08-0.15	118	143	7
Thailand, 1986	0.88	137	167	6

[1]Hernandez, (1993).

Aside from pesticides and heavy metals, hazardous and toxic pollutants include paint and color agents, organic solvents, and other byproducts of industrial manufacturing or processing. Hazardous wastes are products having one or more of the following features: explosive, inflammable, reactive, disease-causing, corrosive, and/ or toxic (based on toxicological tests) (Agenda 21-Indonesia, 1997). Hernandez, (1993) estimated production rates of hazardous waste for a number of South China Sea countries (Table 3.52). The data in this table are estimates derived from various sources, with some as current as 1993 and others pertaining to the late 80s. As the same definition of hazardous waste has not been used in all cases, the information is not comparable between countries and should be used only as a crude estimate. There is a need to monitor the production and disposal of hazardous waste and strategically to control these wastes at the source end by advocating the use of cleaner technologies.

3.3.5 Sediments

In aquatic systems, total suspended solids include sediments brought about by erosion of soil material as a result of mining, agriculture, forest clearance, coastal development including land reclamation, and natural processes. Sediments are a major pollutant in coastal waters they have immediate observable impacts including the smothering of coral reefs, and burial of macrophytes like seagrasses and seaweeds. However, very little quantitative data is available in terms of actual sediment load that has entered aquatic systems in the region, and little was obtained from the national reports. Rates of shoaling can be used as indicators of sediment deposition, but, these represent net accumulation of both man-induced and naturally-caused particle movements.

Table 3.53 Land clearance in selected countries (Agenda 21-Indonesia, 1997)

Country	Land area (10^3 km^2)	Forest area (% of land)			Clearance rate with reforestation (km^2/y)	Annual roundwood production (10^3 m^3)	Annual average reforestation (km^2)
Year	***1989***	***1981***	***1986***	***1989***		***1985-87***	***1980's***
US	9,167	31.0	28.9	28.3	13,189	485,760	17,750
Germany	244	30.0	30.0	29.5	No clearance	31,583	620
Australia	7,618	13.9	13.9	13.5	3,189	19,907	620
UK	242	No data	9.0	5.7	2,181	5,082	400
France	550	No data	26.6	26.6	No clearance	39,890	510
Malaysia	329	66.0	60.0	57.8	3,122	32,000	250
Indonesia	1,812	75.0	72.5	60.0	32,335	158,075	1,640
Philippines	298	31.0	24.5	21.5	2,516	35,822	630
Thailand	511	47.0	35.0	28.0	11,826	36,900	310

Data from Table 3.53 can be used as a proxy for tree felling in determining the extent of sedimentation as a function of land clearance. Indonesia topped the list at a clearance rate of over 32,000 km^2 of forest/yr to produce 158 million m^3 of roundwood. Thailand came second in the region with a rate of almost 12,000 km^2/y from 1981 to 1989 to produce 37 million m^3 of round wood. If the slopes of the cleared area are given, an index of erosion can be made, to estimate the amount of sediments that can be moved. Given the data above, sediment loads from cleared land in Indonesia would have contributed the most sediment, followed by Thailand, Malaysia and the Philippines.

A similar exercise can be done for the mining sector and for land reclamation projects. Both activities produce a large amount of sediment that is transported by rivers in the case of mining, or dumped directly in to coastal waters as filling. The Baguio Mining district, during its peak operations in the 1980's, produced at least 11 million tons of tailings/year that were conveyed by two river systems draining into the Lingayen Gulf (Maaliw, 1990).

Dredging of silted navigation channels can also indicate the massive amounts of sediments brought to aquatic environments. In the Mahakam River Delta, around 2 million m^3 of sediments were dredged to maintain navigation channels, which presumably were silted by erosion caused by massive logging in the interior of Kalimantan (Hinrichsen, 1998).

The responses of flora to reduced light intensities in turbid coastal waters are variable. Under natural processes of erosion, silt load is trapped by mangrove roots in estuarine waters, and then bound by the rhizomes of seagrasses, as they approach the coral reefs. During massive sediment loads, these natural sediment filters break down. For filter feeders like coral polyps, suffocation leads to death as particle removal through tentacular movement is greatly restrained under high silt load. For seagrasses and seaweeds, a reduction in light regimes leads to their demise, and reduced productivities of those plants which can normally deal with relatively higher concentrations of silt and high nutrient regimes of coastal waters. Thus, there is a loss both of biodiversity and productivity of benthic macroflora. In the case of phytoplankton, the massive silt load may not necessarily lead to reduced photosynthesis because cells are suspended in the water column, and shading may be episodic as they are mixed in all directions. The high amount of nutrients associated sometimes with high sediment loads sustains high production. Thus, algal blooms very often are initiated in coastal areas, specifically in embayments.

Reduction of anthropogenic activities which exacerbate erosion, and less disposal of sediments into coastal waters, including reclamation, should be carried out. With population growth and industrialization, there is increasing pressure to provide clear land for housing and infrastructure development in support of industries, and food production. These are clearly political decisions but must be made with minimal negative consequences to the natural resource base on land and in the sea.

3.3.6 Solid wastes

Solid wastes are generated by domestic and industrial activities. There are no reported values in the TDA national reports coming from industries. Table 3.54 compares estimates of reported solid wastes generated by domestic activities and those estimated using a value of 0.6 kg/person/day (Economopoulous 1993). The discrepancies could be in the conversion factor used, as well as in the population estimates. Koe and Aziz, (1995) estimated daily per capita generation of solid waste to range from 0.4 kg in Indonesia to 2.00 in Singapore, the amount increasing with affluence. Using the percent disposal at authorized sites in 1989, the amount disposed in non-authorised locations including rivers and coastal waters would be at least 68% of domestic solid waste production for the entire region. When solid wastes reach aquatic systems, they smother predators, and reduce the aesthetic value of beach and underwater sceneries for coastal tourism.

Although the composition of solid waste from domestic sources is mostly organics (putrescible) and paper, their decomposition rates are slow, and others are not biodegradable such are plastics, metals and glass (Table 3.55). Proper solid waste disposal is a major problem in highly populated areas such as in cities. Landfills when not properly maintained can produce toxic leachates which can seep into groundwater, or aggregate hazardous materials that can impair public safety. In Metro Manila, some landfills have become methanogenic (hence the name Smoky Mountain for a landfill located in a suburb of Metro Manila in Navotas) causing severe respiratory illnesses among residents in surrounding areas.

Table 3.54 Solid waste from domestic sources (based on TDA national reports)

Country	Population of South China Sea subregions X 10^3 (% of national)	Estimated solid waste (10^3 t/y) (at 0.6 kg/person/day)	Reported values of solid waste from domestic sources (10^3 t/y)	Percent disposal at authorized disposal sites (1989)[1]
Cambodia	1,985 (18%)	435	560	No data
China	59,694 (5%)	13,073	No data	No data
Indonesia	105,217 (50%)	23,042	22,899	60%
Malaysia	10,336 (51%)	2,264	1,924	65%
Philippines	23,633 (31%)	5,176	1,330	70%
Thailand	37,142 (62%)	6,134	482	40%
Viet Nam	75,124 (100%)	16,452	No data	No data
Total	**313,131 (19%)**	**66,576**		
2005	359,837	78,804		

[1]data from Koe and Aziz, 1995.

Table 3.55 Components of solid waste (Koe and Aziz, 1995)

Country	Solid waste compositon (%) in some South China Sea countries					
	Paper	Glass	Metals	Plastics	Organics	Others
Brunei	26	6	11	13	41	3
Indonesia	2	1	4	3	87	3
Malaysia	25	3	6	8	56	2
Philippines	10	2	3	9	70	6
Singapore	28	4	5	12	44	7
Thailand	19	6	4	10	55	6

3.3.7 Oil and other hydrocarbons from land and sea-based sources

Table 3.56 Extent of oil pollution in the TDA participating countries (data from national TDA reports. For Indo, Phil. & Thai. assume 1L oil weighs 1kg)

Country	Sources		
	Domestic sources (t/y)	Industrial Sources (t/y)	Ship-based/ Platform operations (t/y)
Cambodia	No data	No data	No data
China	No data	187.00	>300
Indonesia	No data	No data	32.8
Malaysia	No data	0.52	No data
Philippines	No data	No data	0.86
Thailand	No data	No data	> .01
Viet Nam	2,132	No data	>4,280

Figure 6. Pollution "Hot Spots" in the South China Sea. Numbers correspond to location listed in Table 2.3.

The data in Table 3.56 is not sufficient to establish the relative importance of each of the major sources of oil and other hydrocarbons in the aquatic environment. For lack of regionally based data, the following estimates (GESAMP, 1993) for the global ocean may hold true for the South China Sea (Table 3.57).

Table 3.57 Relative contribution of different sources to oil pollution

Sources	Inputs (t/y) (% contribution)
1. Municipal and industrial sources	1,175,000 (50%)
2. Marine transportation	564,000 (24%)
3. Atmosphere	305,500 (13%)
4. Natural sources	258,500 (11%)
5. Offshore production	47,000 (2%)

The relative contribution of various sources of oil will vary depending on factors including population density, extent of shipping, mineral exploration, and the degree of industrialization of littoral countries. In the South China Sea, all factors are intensifying so that absolute oil inputs will increase from at least three sources (Table 3.57). The average annual growth rate for oil demand in five of the seven TDA participating countries is projected to be 5% for the period 1993 to 2005.

Table 3.58 Oil demand by selected countries (10^3 barrels/day) (*GEF*/*UNDP*/IMO 1997)

Country	1993	2000	2005	Average annual growth for, 1993-2005 (%)
China	2,743	4,031	5,001	5.1
Indonesia	756	1,170	1,556	6.2
Malaysia	290	414	522	5.0
Thailand	517	839	1,096	6.5
Philippines	253	367	466	5.2
Japan	4,822	5,086	5,188	0.6
South Korea	1,552	2,217	2,740	4.8
Asia-Pacific	14,197	18,469	21,630	3.6

GESAMP (1993) summarizes the salient effects of oil on a number of marine organisms. Birds coated with oil during major spills have high mortality rates, but their long-term impacts on populations across generations are difficult to establish. High concentrations of oil in critical areas, including spawning and recruitment grounds, have an impact on the viability of populations including reducing the number of potentially reproducing adults. Mangroves are very susceptible to stress by oil because of the clogging of their aerial roots or pneumatophores. As a consequence, they suffer from partial or full defoliation, and may take as long as 20 years to recover. For corals, species accommodate oil contamination along a gradient of tolerance and the associated biota of coral reefs is impacted adversely, especially the young life stages of crustaceans and echinoderms. The water-soluble fractions of oil are the most lethal components. Tainting of food species has yet to be established. It is evident that oil interferes with lipid metabolism but the components of oil residuals and the substances that bind on organisms are unknown, much less their potential impacts on man.

Figure 7. Total nitrogen loading in sub-divisions in the South China Sea.

3.3.8 Atmospheric sources

Emissions from power generation, industries and transportation contribute greatly to airborne pollution. By far, the most significant contributor is the power sector (Agenda 21-Indonesia, 1997). Fuel used for power generation includes fuel and diesel oil, coal and natural gas. Oil and coal are the most common fuels used in South China Sea countries (Table 3.58). The most pollutive of all fuels is coal in increasing intensity as its quality decreases. Most countries opt to use low-grade coal to produce cheaper energy, but the environmental impacts and effects on human health are most severe. The use of cleaner, albeit more expensive, fuel is in fact cheaper than lower quality fuel with its associated costs for the appropriate treatment of noxious emissions and human illnesses, even in the short term (Agenda 21 – Indonesia, 1997).

In urban areas, transportation is responsible for the release of most air pollutants. The number of vehicles will most likely increase to meet the transportation demands of a growing population. Considering only South China Sea-related subregions, Thailand has the most number of vehicles, followed by Indonesia, Malaysia and the Philippines. China and Viet Nam, with their increasing involvement in free trade, will spur the growth of the transport industry. In Jakarta, transportation accounts for 100% of lead, 42% of suspended particulate matter, 89% of hydrocarbons, 64% of nitrous oxides and 100% of carbon monoxide (Agenda 21-Indonesia, 1997). The profile may not be very different for other cities in South China Sea countries.

Sulphorus and nitrous oxides have profound impacts on human respiratory systems. When hydrated by precipitation, these ions form acid rain, a phenomenon that has considerably altered aquatic and terrestial systems in the Northern Hemisphere. The long-range transport of atmospheric pollutants is of transboundary and global concern. Indonesian subregions interacting with the South China Sea are rained on with 1.2 million tons/yr of sulphate. In Thailand and over a smaller area in its central and eastern sections, about 350,000 tons of sulphate goes back to the watershed annually (Table 3.59). Air shed-scale studies are needed to elucidate the transboundary dynamics and transport of acid precipitation in the South China Sea region during normal and anomalous climatological conditions.

Table 3.59 Atmospheric pollution in TDA participating countries.
(Data from National TDA Reports)

Country	Oil consumption (10^3 t/y)	Coal consumption (10^3 t/y)	Number of vehicles (10^3 units)	Forest fires (affected area, ha)	Volcanic eruptions (in the last 50 years)
Cambodia	1,089	No data	No data	No data	No data
China-South China Sea	13,094	62,641	2,260	No data	No data
Indonesia-South China Sea Indonesia -Nat	No data 33,580	No data No data	8,951 14,886	No data 263,992 ha in 1997	7 eruptions
Malaysia-South China Sea	No data	No data	2,725	No data	No data

Continued Table 3.59

Country	Oil	Coal	Number of	Forest fires	Volcanic

	consumption (10^3 t/y)	consumption (10^3 t/y)	vehicles (10^3 units)	(affected area, ha)	eruptions (in the last 50 years)
Philippines-South China Sea	10.25 X 10^6 barrels	118.05 X 10^6 barrels	2,062	2,851 ha in 1997	2 eruptions
Thailand-South China Sea	No data	No data	11,050	No data	
Viet Nam	No data	No data	No data		

Table 3.60 Composition of precipitation in Indonesia and Thailand
(Data from National TDA Reports)

Indonesia-South China Sea	Rainfall (mm)	Area (km^2)	SO_4 (t/y)	H^+ (moles/yr)	NH_4
Riau-Batam	1,719	94,561	185,729	307,022	172,493
Bangka-Belitung and South Sumatra	1,868	103,688	132,322	313,350	141,605
West Java	858	46,890	155,195	139,489	6,486
East Java	941	47,921	251,294	165,861	25,096
S. Kalimantan	1,644	37,660	196,096	313,823	41,256
W. Kalimantan	2,550	146,760	278,103	437,593	91,303
Subtotal			**1,198,739**	**1,677,138**	**478,239**
Thailand-South China Sea					
Central	1,304	64,044	67,802	42,919	4,927
Eastern	2,142	36,502	286,681	146,781	21,740
Subtotal			**354,483**	**189,700**	**26,667**

3.3.9 River systems

Table 3.61 shows fluxes from rivers in the seven TDA participating countries. Fluxes, obtained by multiplying average concentrations with annual discharge rates, indicate the amount of material conveyed by river systems to the sea, as a combination of load from all sources (agricultural, domestic and industrial). Concentrations at discharge points, are a net result after uptake by organisms, adsorption to particles, and chemical speciation have proceeded, among others. They indicate in what concentrations pollutants finally enter the coastal waters of the South China Sea. Excluding the archipelagic countries where either appropriate data is wanting or wrongly estimated, rough estimates of the total for the five continental countries are indicated. Rivers in Cambodia, China, Malaysia, Thailand and Viet Nam deliver at least 636, 840 tons of nitrogen to coastal waters overlying the Sunda Shelf. Of these, China contributes at least 55%, since they only reported inorganic N. Viet Nam (NO_3-N) and Thailand (DIN), contributed 21 and 20%, resp.

Table 3.61 Pollutant fluxes from rivers of TDA participating countries
to the South China Sea

Country/River	Catchment Area (km^2)	Annual discharge (km^3)	BOD (t/y)	Total N (IN) (t/y)	Total P (IP) (t/y)	TSS (t/y)	Oil (t/y)
Cambodia							
Tonle Sap Lake-	69,355	36.45	6,022	1,084	303	13,250	No data

River System							
Coastal rivers	13,406	21.79	No data	No data	No data	No data	No data
Mekong River, Cambodia section	72,060	128.38	4964	894	255	10,950	No data
China							
Guangdong: Han, Rong, Pearl, Moyang, Jian	488,802	422.20	566,385	(340,050)	(3,768)	58,531,000	9,698
Quangxi: Nanliu, Qing, Maoling	14,051	24.90	57,668	(8,602)	(507)	No data	823
Hainan: Nandu, Changhua, Wanquanhe	15,865	31.0	140	No data	No data	No data	368
Indonesia							
Rivers in Jakarta and West Java	14,241	30.7	7,778,716	1,015,013	No data	22,368,391	1,549,979
Malaysia				**Ammonia-N**			
54 rivers	231,000	No data	>81,500	>20,100	No data	>75,000	1
Philippines							
No data	No data	No data	No data	No data	No data	No data	No data
Thailand				**DIN**			
Central, Eastern, Southern rivers	320,553	144.2	299,224	130,044	7,137	12,587	No data
Viet Nam				**NO_3-N**	**PO_4**		
	1,316,701	942.0		135,374	46,232		
			Cu	**Pb**	**Cd**	**Zn**	**Hg**
Thai Binh	28,230	46.26	3,942.2	154.3	163.9	3,352.0	16.5
Red	298,050	200.00	2,817.0	730.0	118.0	2,015.0	11.0
Dong Nai-Sai Gon	47,280	50.50	No data	102.2	No data	77,015.0	25.6
Mekong	830,780	573.10	1,825	190	128.0	1,278.0	<13.0
			BOD	Total N	Total P	Total TSS	Total Oil
>Total South China Sea for continental countries			**1,000,000**	**637,000**	**58,000**	**58,600,000**	

In general, river systems in the TDA participating countries, with the exception of Cambodia and Malaysia are moderate to heavily polluted using standard water quality parameters (Table 3.62). This is especially evident in rivers running through thickly populated areas such as in cities of China, Indonesia, Philippines, Thailand and Viet Nam. The mouths of these rivers are pollution hot spots, and mitigation at the source end from both point and diffuse sources will have to be dealt with.

Table 3.62 Status of river systems in TDA participating countries

Country	Status of River Systems
Cambodia	**Mekong River (Cambodia segment)**: OK
	Tonle Sap Lake-River system: moderate eutrophication during dry season
China	**Pearl River:** discharges 87% of the total COD coming from Guangdong Province; a pollution hot spot
Indonesia	Majority of the rivers on the island of Java empyting into the South China Sea are moderate to heavily polluted.
Malaysia	None of the rivers empyting to the South China Sea are classified as being heavily polluted from agro-based and manufacturing-based industry.
Philippines	**Pasig River**: Biologically dead **Rivers draining into Lingayen Gulf:** moderately polluted, but may have heavy metal contamination from the Baguio mining district.
Thailand	The final 100 km of the Lower Chao Phraya, Petchburi, Bangpakong, Rayong river systems emptying into thre Gulf of Thailand are pollution "hot spots". They convey 50% of total pollution to the Gulf.
Viet Nam	Six river systems (Ky Cung-Bang Gang, Red, Ma, Ca, Dong Nai, Mekong) are transboundary; Red, Dong Nai-Sai Gon, Mekong and Thai Binh Rivers have exceeded allowable limits for heavy metals like Hg and As.

3.3.10 Pollution hot spots, high-risk and sensitive areas

The TDA national reports identified 35 pollution hotspots (Table 3.63 and figure 6) and 26 sensitive and high-risk areas (Table 3.64) in sub-regions interacting with the South China Sea. Pollution loads on aquatic environments are influenced by population distribution and growth, industrial and agricultural development inland as far as catchments extend. The hot spots represent priority areas for monitoring and mitigation since they are places where pollutant load is most concentrated and will have the most impact on natural systems and public health. High risk and sensitive areas indicate locations which need the most protection from continued pollutant loading considering their limited assimilative capacities, their high biodiversity and the key ecological support function they provide. Previous sections on habitat modification have noted that virtually all coastal habitats (mangroves, corals and seagrasses) as well as natural wetlands in the region are sensitive areas and are at high risk. From a regional perspective, the locations of all the identified key areas relative to one another considering circulation regimes and prospective development, are necessary information in inferring the transboundary features of issues related to pollution.

Table 3.63 Pollution hot spots in TDA participating countries (National Reports)

Location	Demography/ Contributing cities or subregions	Pollution load
Cambodia		
1. Phnom Penh City	1,100,000 (1997)	BOD: 20,075 t/y TSS: 44,165 t/y COD: 34,130 t/y Total N: 3,285 t/y Total P: 1,000 t/y
China		
2. Han River	Shantou	COD: 37,102 t/y Oil: 384 t/y IN: 4,296 t/y IP: 697 t/y
3. Pearl Estuary	Hong Kong, Shenzhen, Dongguan, Guangzhou, Zhuhai, Macau	COD, nutrients, SS
4. Zhanjiang Bay	Zhanjiang	COD: 11,691 t/y N: 840 t/y Oil: 190 t/y
5. Behai coastal waters	Behai City	COD, nutrients, SS
6. Haikou coastal waters	Haikou	COD, nutrients, SS
Indonesia		
7. Dumai River	Riau –Batam	BOD: 17.7 – 48 mg/l
8. Pulau Nipah	Riau-Batam	
9. Siburik River	Bangka-Belitum and S. Sumatera	NO_3: 1.38 – 2.14
10. Lahat River	Same	BOD: 3 – 35 mg/l
11. Tanjung Pandan	Same	Cd: 0.005 – 0.017 mg/l
12. Palembang Harbour	Same	BOD: 4 –78 mg mg /l
13. Japat River	Jakarta	BOD: 13.5 – 15.0 mg/l
14. Jakarta Bay	Jakarta	Hg: 0.132 – 0.200 ug/l
15. Kali Mas River	West Java	BOD: 15.6 – 47.0 mg/l
16. Strait of Madura	West Java	BOD: 48 – 91 mg/l Phenol: 0.05 – 1 mg/l
17. Pulau Laut	S. Kalimantan	NO_2-N: 0.03 mg/l
18. Pontianak Harbour	W. Kalimantan	BOD: 135 – 150 mg/l
Malaysia		
19. Kota Bharu	257,792 (population); 0% access to sewerage	BOD generated: 4,705 t/y
20. Kuala Terengganu	268,294; 8.6% access	BOD generated: 4,477 t/y
21. Kuantan	238,738; 24% access	BOD generated: 3,230 t/y
22. Kuching	497,000; no data	BOD generated: 9,070 t/y
23. Kota Kinabalu	271,000; no data	BOD generated: 4,946 t/y

Continued Table 3.63

Location	Demography/ Contributing cities or subregions	Pollution load
Philippines		
24. Manila Bay	Metropolitan Manila and CALABARZON industrial estate	BOD: 4.8 mg/l Coliform: 2.5 x 10^5 ppm
25. Subic Bay	Zambales specifically Subic Port and industrial estate	BOD: 160-234 mg/l Coliform: 1,888 MPN/100 ml
26. Batangas Bay	Batangas City, oil refineries and depots	BOD: 8,838 t/yr from livestock Oil: 1,233 m^3 spilled from 1986-1993
Thailand		
27. Lower Chao Phraya River		Water Quality Index Level 5
28. Pasak River		Same
29. Petchburi River		Same
30. Bangpakong River		Same
31. Rayong River		Same
32. Songkhla Lagoon		Same
Viet Nam		
33. Ha Long Bay	Open pit coal mining, oil depots, port operations	4 x 10^6 t of coal mine sludge/y
34. Hai Phong Port	Population of 564,200; 9,891 industrial firms, 3.5 x 10^6 ton port.	BOD: 3,235 t/y COD: 4,331 t/y Coliform: 1,500 MPN/ 100 ml
35. Da Nang Port	Population of 667,200; 767 industrial firms, 3 oil ports	COD: 3,236 t/y TN: 6,601 t/y TP: 62.4 t/y TSS: 194,316 t/y Coliform: 5-270 x 10^3 MPN/100 ml
36. Vung Tau- Ganh Rai	154,505 population; 2,622,000 tourists/y (1995)	Ganh Rai Bay BOD: 4-11 mg/l SS: 150-260 mg/l TN: 0.2 - 0.5 mg/l TP: 0.02 – 0.05 mg/l Oil: 0.15 – 0.25 mg/l Zn: 0.02 – 0.04 mg/l

Table 3.64 Areas at high risk (HR) and sensitive (S) to pollution in the TDA participating countries (national reports)

Location	Pressures/ Sensitive resources	Pollution risks
Cambodia		
1. Sihanouk Ville – HR	55,440 population; 20 factories; port capacity of 1.2 x 10^6 tons	BOD: 1,011 t/y COD: 1,720 t/y TSS: 2,226 t/y
2. Tonle Sap Lake – S	Urban centers of Kompong Chnang, Pursat, Battambang, Siem Reap, Kompong Thom	Biodiversity and productivity of the largest permanent freshwater lake in Southeast Asia: part of the transboundary Mekong River Basin
China		
3. Daya Bay, Huizhou City – HR		Pollution from Daya Bay; oil spills from oil terminal
4. Shuidong Port, Maoming City – HR		Oil spills from oil terminal
5. Coastal waters of Sanya City – HR		Pollution from rivers, Sanya City population, coastal industries
6. Yangpu Bay - HR		Industrial pollution
7. Green Turtle Preserve, Huidong Port - S	Green turtle	Near river mouths; with high social and natural value
8. Aquatic Resource Preserve, Daya Bay – S	Aquatic resources	Same
9. Futian Natural Preserve – Deep Bay – S	Aquatic resources	Same
10. Haikang Preserve at Leizhou Bay – S	White butterfly shellfish	Same
11. Dugong Preseve, Tieshan Port Bay – S	Dugong	Same
12. Shankou Mangrove Preserve, Tieshan Port Bay – S	Mangroves	Same
13. Behai Beach - S	Natural landscape	Same
14. Mangrove Reserve, Beilun River mouth – S	Mangroves	Same
15. Mangrove Reserve, Dongzai Port – S	Mangroves	Same
16. Haikou City Beach - S	Natural landscape	Same
Indonesia		
17. Degraded areas in Java, Sumatera, W. Kalimantan	No data given	No data given
Malaysia – No locations given		

Continued Table 3.64

Location	Pressures/ Sensitive resources	Pollution risks
Philippines		
18. Masinloc Bay – HR		Red tide occurences
19. Bacuit Bay, Palawan – S, HR		Offshore oil and gas development
20.Oceanic shoals – S	Marine protected areas for marine turtles and sea birds	Shipping and oil spills
21. Apo Reef, Mindoro Strait – S	Marine protected areas for coral reefs	Shipping and oil spills
Thailand		
22. Head of Upper Gulf – HR		Receives polluted water from 4 rivers; Limited exchange between near and offshore waters; Bangkok Bar Channel isa navigational hazard
23. Ban Don Bay – S	Shellfish culture, coral reefs and seagrass communities; spawning grounds of Indo-Pacific mackerel	Loading from Tapipum Duong river
24. Rayong – S, HR	Coral reefs and seagrasses	Petrochemical industries; oil spills
25. Songkhla Lagoon – HR		Contaminated brackish waters with high BOD and coliform bacteria
Viet Nam		
26. Red River Delta – HR, S	Mangroves, shrimp and fish grounds, shore birds	Red River: Cu: 5.7 – 19.2 ug/l Hg: 0.02 – 0.25 ug/l As: 6.5 – 20.4 ug/l Zn: 22.8 – 53.3 ug/l
27. Mekong Delta – HR, S	Mangroves, shrimps and fish grounds	

3.3.11 Transboundary issues associated with pollution

Transboundary transport of pollutants occurs through international rivers, following circulation along the shared Sunda Shelf, and through the atmosphere. Economic activities like coastal tourism and the trade of waste are anthropogenic agents of pollution transport across national boundaries. The quality of this information is generally poor (Table 3.65).

Table 3.65 Transboundary issues associated with pollution in TDA participating countries

Transboundary Issue – Quality of Information	**Ca**	**Ch**	**In**	**Ma**	**Ph**	**Th**	**Vi**
1. Pollution of transboundary rivers							
• Mekong River – Poor to Fair	✓	✓				✓	✓
• Red River – Fair (Viet Nam)		✓					✓
• Sai Gon-Dong Nai–Fair (Viet Nam)	✓						✓
2. Transport of polluted coastal waters along the Sunda Shelf–Poor	✓	✓		✓		✓	✓
3. Haze from forest fires – Poor			✓	✓	✓		
4. Acid precipitation – Poor		✓				✓	✓
5. Transport of waste for trade and recyling – Poor	No data	✓	✓	✓	✓	✓	No data
6. Coastal tourism – Fair	✓	✓	✓	✓	✓	✓	✓

Pollution of international rivers. Six countries, four of which are TDA participants, share the Mekong River. China, specifically the Yunnan Province, sits at the source of the Mekong, while Thailand, Cambodia and Viet Nam are mid- and downstream of the river flow before it empties to the South China Sea through the Mekong River Delta. Two pollutants have transboundary impacts on the river basin. These are organochlorines and sediments. The data base for the presence of organochlorines is limited but is listed by the Mekong River Commission (1997), because of the rapidly expanding use of persistent organic pollutants (POPs) in the agricultural sector. All MRB countries contribute to sediment load. In Cambodia, the merging point of the Tonle Sap River with the Mekong has high TSS loads. The same is true for where the Bassac River joins the Mekong in Viet Nam. Poor land use management in the Yunnan highlands with an average slope of 32.3%, has caused significant erosion in 29% of the basin of the Lancang River (Mekong River) within China (Tables 3.66 and 3.67).

Table 3.66 Sharing of Mekong River Basin water resources (Mekong River Commission, 1997)

Resource	**Yunnan, Chi**	**Mya**	**Lao**	**Tha**	**Cam**	**Vie**	**MRB**
Catchment area (km^2)	147,000	24,000	202,000	184,000	155,000	65,000	777,000
Catchment area as % of nation/province	38%	4%	97%	36%	86%	20%	--
Catchment area of % of total MRB	22%	3%	25%	23%	19%	8%	100%
Annual flow (10^6 m^3)	76,500						475,000
Average flow (m^3 /s) from area	2,410	300	5,270	2,560	2,860	1,660	15,060
Average flow as % of total MRB	16	2	35	18	18	11	100

Table 3.67 Water quality assessment of the Mekong River Basin
(Mekong River Commission, 1997, National reports)

Factor	Severity	Spatial scale	Occurrence/ Remarks
Eutrophication	Moderate-severe	local	Development areas High N conc: Chiang Saen, Ban Kok, Yasothon, Ubon, My Tho High P conc: Vientiane, Ban Kok, Luang Prabang, My Tho
Organic pollution	Severe-moderate	local	Development areas
Salinity	Very severe	local	Korat Plateau (evaporite rock salt) Salt water intrusion in Delta
Toxic metals	moderate	local	Limited data Severe in mining areas of western Cambodia; Severe in Viet Nam
Microbial pollution	moderate	local	Development areas
Acidification	severe	local	Delta
Organochlorines	moderate	regional	Limited data
Sediment yields	Moderate-severe	regional	Higher upstream and in wet season

Six of the 10 major river systems in Viet Nam are transboundary in extent (Table 3.68). Of these, four are severely polluted with BOD, nutrients, sediments and toxic heavy metals. Because they are shared water resources, pollution management will have to be pursued by user countries, with due consideration that impacts are felt downstream. All resource users should equitably and effectively control pollution and prevent further degradation.

Table 3.68 Transboundary river systems in Viet Nam
(ESCAP, 1995, Viet Nam National Report)

River system	Catchment area (km^2)	River flow volume (km^3/y)		Status
		From outside (% of total)	Total	
Red-Thai Binh	168,700	44.12 (19)	137.00	Severe heavy metal pollution
Bang – Ky Kung	12,880	1.70 (32)	8.92	No data
Ma-Chu	28,400	4.34 (22)	20.10	No data
Ca	272,000	4.74 (20)	24.20	No data
Dong Nai	42,665	1.41 (5)	30.60	Severe heavy metal pollution
Mekong	795,000	500.00 (96)	520.60	Severe heavy metal pollution

Transport along the Sunda Shelf. China, Viet Nam, Cambodia, Thailand, Malaysia, and to a small extent Indonesia, share the Sunda Shelf. Few studies show the possibility of long-shore transport of pollutants across national boundaries. The Viet Namese report indicates that transport of pollutants from its northern pollution hot spots (Red-Thai Binh river mouths, Ha Long City, Hai Phong Port) can influence Hai Nan coastal waters and those along the coast of Quang Chau. Hot spots located south (Sai Gon-Dong Nai River, Mekong River, Vung Tao) can impact the waters of Cambodia, Thailand and Malaysia. Furthermore, oil spills in the Gulf of Tonkin, and along the South Viet Nam shelf can reach China to the north, or Cambodia, Thailand and Malaysia to the south, depending on the prevailing monsoon. (Viet Nam TDA National Report)

Jacinto *et al*., (1997) discussed the use of nutrients as tracers of water masses in explaining both the horizontal and vertical nutrient profiles across a cruise track between the Philippines and Viet Nam. Nutrient concentrations were higher in stations nearer the Viet Nam shelf (average values of 2 μM for nitrate, 0.35 μM for nitrite, 1.8 μM for ammonia, and 0.70 μM for phosphate in the top 50 m), and within higher temperature and lower salinity regimes compared to adjacent stations. These could indicate runoff water, with the boundary current flowing south along Viet Nam interacting with waters from rivers flowing out of Viet Nam and Thailand.

Long-range atmospheric transport. Forest and grass fires occurred in Indonesia and the Philippines in 1998 at the height of the warm phase of the ENSO. In both countries, forest fires resulted from land clearing for estate plantations, transmigration and animal ranching; spontaneous combustion of coal seams, and those caused by lightning and volcanic eruptions (Agenda 21-Indonesia, 1997). The extent of the fires was significant enough to cause smoke to spread over Palawan, western Philippines, Peninsular Malaysia and Singapore.

Transport of other pollutants along air sheds may not be as visible as haze or smoke pollution, but may be more insidious. The long-range transport of sulfur and nitrous oxides through air masses, leads to transboundary acid precipitation. A report by Canadian Environmental Collaborative (1993) states that acid precipitation occurs in southern China (Sichuan and Hunan Provinces) during the summer months, and affects northern Viet Nam and Laos. During winter, with prevailing winds coming from the southwest, pollutants from Thailand and the rest of the Indo-China Peninsula could be contributing to acid precipitation in coastal southern China. The data are sparse, and when available can yield conflicting models of wind transport. Thus, large scale studies on atmospheric chemistry are a priority concern in the region.

Illegal Waste trade. Waste is transported from source developed countries for dumping (at sea) or for disposal and/or recycling in developing countries. Very little information exists because of the usually illegal nature of waste transport, especially noxious wastes. Media highlights transport of nuclear fuels or wastes, but other equally dangerous waste substances seem to be part of the regular trade traffic. Agenda 21-Indonesia (1997) documents the export of plastic garbage from the US during the months of February-March, 1992 to recipient countries in Asia for recycling (Table 3.68), 73% of which went to China. In certain instances, the cargo was declared as raw materials. Signatories to the Basel Convention, which attempts to regulate the trade and disposal of toxic and hazardous wastes, should be able to address this particular issue, but only if there is strong political will to counter economic exigencies driving the waste trade. Large quantities of noxious but unidentified waste was transported from Taiwan of China to Sihanoukville in Cambodia in 1999 but international presure forced Taiwan of China to remove it. (Bangkok Post 16/2/99, 11/4/99, 17/6/99)

Table 3.69 Transboundary transport of waste for recycling from USA (February 1 – March 31, 1992) (Agenda 21-Indonesia, 1997)

Receiving Country	Shipments	Total kg x 10^3
China	598	17,410
Indonesia	50	2,251
Japan	5	51
Korea	8	110
Malaysia	7	255
Philippines	58	2,448
Thailand	6	124
Total (including other countries)	**749**	**23,740**

Coastal tourism. (See section on transboundary issues associated with habitat degradation). Tourism, along the coastal areas of the South China Sea, is dependent on clean beaches and coral reefs. Tourism has contributed significantly to coastal pollution and the degradation of corals, mangroves, beaches and seagrasses. The infrastructure development needed to support coastal tourism and the waste generated by facilities which crowd prime beach areas are traditionally taken as necessary evils that countries must accept in generating tourism-based revenues. As the industry increases (see Table 3.19) these issues must be considered and remediative and environmentally sound management brought into general practise. Tourism cannot be taken on its own, rather the environmental and socio-economic effects on a local and regional basis should be taken into consideration.

Table 3.70 Status of wetlands and associated biodiversity summarized from Scott (1989).
(Note: Strictly, coastal wetlands including saline lagoons and mangrove areas were not included below.)

Country: Cambodia

Site description	Area	Economic & Social values	Disurbances & threats	Biodiversity	Conservation measures taken
Mekong River: Associated freshwater swamp forests but widely deforested for firewood and agricultural land	486 km river; 2 M ha of floodplain which includes 1.6 M ha of the Mekong Delta	Supports one of the world's largest inland fisheries (75,000 to 80,000 t for the area from Kratie to Vietnamese border in the 1970s)	➢ proposed irrigation, hydroelectric power projects, flood control structures ➢ deforestation and demand for agricultural land; Cambodian portion of Mekong Delta has 1 M ha under cultivation, almost 90% of which is for rice ➢ domestic wastes and agricultural runoff	➢ principal tree species in swamp forest are *Barringtonia acutangula, Hydrocarpus anthelmintica, Terminalia chabula, Homalium brevidans, and Amelia asiatica* ➢ dry season fish fauna: 54% Cyprinidae or carps; 19% catfish; 8% murrels; & 19% (featherbacks, herring, climbing perch and gouramis, others) ➢ endemic fish include migratory catfish *Pangasianodon gigas* ➢ 3 species of dolphins: Irrawaddy dolphin *Orcaella brevirostirs*, Chinese white dolphin *Sotalla chinensis*, Black finless porpoise *Neophocaena phocanoides* ➢ wetland mammals: smooth-coated otter *Lutra perspicillata,* fishing cat *Felis viverrina*	None

Cambodia (con't)

Site description	Area	Economic & Social values	Disurbances & threats	Biodiversity	Conservation measures taken
Great Lake and Tonle Sap River: ➢ Great Lake, largest permanent freshwater lake in SE Asia ➢ Great Lake connected to the Mekong via the Tonle Sap River ➢ Lake surrounded by freshwater swamp forest, 20-30 km wide, and which in turn are surrounded by a belt of rice paddies up to 25 km wide	➢ Lake area in dry season cover approx. 300,000 ha; in wet season, 1.1 to 1.3 M ha ➢ 1960 estimate of swamp forest was 681,400 ha; 1986 estimate is 564,000 ha	➢ Great lake regulates Mekong floods ➢ fisheries exploitation mostly carried out by straining fish during recession of floodwaters; lake commercial fish productivity estimated to be 40-50 kg/ha/yr or a total of 36,000 t/yr; ➢ total annual fishery estimated to be 139,000 t in 1939-51; 101,700 t in 1956-61; between 50,000 to 80,000 t in early 1970s; and 63,000 t in 1984 ➢ rice cultivation in the paddies	➢ clearance of swamp forest for agriculture, firewood and fishponds ➢ siltation resulting from deforestation	➢ swamp forest as in those around the Mekong River ➢ 38 commercially important fish species ➢ several breeding colonies of large waterbirds including endangered species such as the milky stork *Mycteria cinerea,* giant ibis *Thaumatibis gigantea,* white-shouldered ibis *Pseudibis davisoni,* and the eastern sarus crane *Grus antigone sharpii* ➢ mammals include Eld's deer *Cervus eldi* and Banteng *Bos javanicus*	Angkor Wat National Park of 10,717 ha established in 1925 includes 2,000 ha of swamp forest

Cambodia (con't):

Site description	Area	Economic & Social values	Disurbances & threats	Biodiversity	Conservation measures taken
Stung Sen: ➢ with large areas of seasonally flooded marshes and grasslands along riverbanks; ➢ clearance of original dipterocarp forests led to formation of savanna grasslands with patches of mixed deciduous and dry dipterocarp forest	About 120 km of the Sen River; area of wetlands unknown	➢ sparsely populated ➢ hunting of mammals	➢ civil war with soldiers hunting for game meat	➢ tree species include *Shorea obtusa, Dipterocarpus obtusifolius, D. tuberculatus, Pentarme siamensis;* ➢ waterfowl as in the Great Lake-Tonle Sap system ➢ Siamese crocodile *Crocodylus siamensis* ➢ Grasslands supported herds of Kouprey, Banteng, Gaur, eld's deer, asian elephant and wild water buffalo, tiger and leopard	None
Stung Kaoh Pao and Stung Kep Estuaries: A complex of tidal channels and creeks, low islands, mangrove swamps, tidal mudflats and coastal lagoons of the Kaoh Pao and Kep rivers	Approx. 30,000 ha including 16,000 ha of mangrove forests	No information	No information	➢ Flora mostly mangrove forest; evergreen and deciduous forests of the Cardamome Range ➢ Fauna not known	None

Country: China

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Lufeng Marshes, Guangdong Province: estuarine system with fresh to brackish lagoons, marshes, mangrove swamps and intertidal mudflats	Approx. 2,000 ha	No information	No information	➢ Mangrove forest with about 20 species ➢ Important wintering and staging area for migratory shorebirds	None
Futien Nature Reserve, Guangdong Province: mangrove swamps, intertidal sand flats and mudflats along Hau Hoi Wan and the Shenzhen River; contiguous with the Mai Po Marshes in Hong Kong	About 304 ha including 228 ha of mangroves	➢ Fish and shrimp ponds along Hau Hoi Wan (Deep Bay) ➢ Mudflats support an important oyster fishery	Pollution from agricultural and domestic waste and from industrial development upstream of the Shenzhen River	➢ Seagrass *Halophila* on the mudflats ➢ Mangroves include *Kandelia candel, Aegiceras corniculatum, Avicennia marina, Excoecaria agallocha, Acanthus ilicifolius, Bruguiera gymnorhiza, Sonneratia acida, Rhiziphora stylosa, Derris trifoliata;* mangrove fern *Acrostichum aureum* ➢ 18 species of lamellibranchs, 10 gastropod sp.; 7 crustacean species ➢ Bennett's water snake *Enhydrus bennetti* Bird species include resident herons and egrets like *Ardeola bacchus, Egretta garzetta, Ardea cinerea;* wintering waterfowl such as *Tachybaptus ruficollis, Phalacrocorax carbo;* ducks including *Tadorna tadorna, Anas crecca, A. poecilorhyncha, Aythya fluigula, Fulica atra;* migratory shorebirds mainly *Charadrius alexandrinus, Calidris alpina* and gulls *Larus ridibundus*	The whole area is within the Futien-Nei Lingding Provincial Nature Reserve (858 ha) established in 1984: ➢ Sand extraction, wood cutting and hunting are prohibited ➢ Existing fish and shrimp ponds in use but no new construction is allowed ➢ *Acacia confusa* trees planted to shelter the mangrove fringe

China (con't.)

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Xi Jiang (Pearl River Delta), Guangdong Province: includes interconnecting river channels, low islands, riverine marshes, intertidal mudflats	475,000 ha	➢ One of China's most important fishing areas ➢ Delta is heavily used for aquaculture and agriculture	➢ Mangrove conversion to fish ponds ➢ Infrastructure for drainage, and reclamation ➢ Pollution from agricultural, industrial and domestic waste ➢ Hunting of shorebirds for food and export	➢ Few mangrove patches remain ➢ Important wintering area for Anatidae, and for migratory shorebirds; nesting species include *Nycticorax nycticorax, Ardeola bacchus, Bubulcus ibis, and Egretta garzetta*	A tiny nature reserve, the Bird Paradise Nature Reserve, was established to protect a breeding colony of *Nycticorax nycticorax*
Beijin Gang, Guangdong Province**:** brackish marshes, mangrove swamps and intertidal mudflats	1,500 ha	No information	No information	➢ Mangrove forest ➢ Migratory shorebirds	None
Dongzaigang Nature Reserve, Hainan: Small shallow bay with intertidal mudflats and mangrove swamps	5,240 ha	➢ Fiheries ➢ Agriculture	➢ Densely populated ➢ Overfishing	➢ Mangrove forest with *Bruguiera gymnorhiza, B. sexangula, Rhizophora stylosa, Ceriops tagal, Lumnitzera racemosa, Heritiera littoralis, Excoecaria gallocha, Aegiceras corniculatum* ➢ Rich fish fauna ➢ Feeding habitat for waterfowl including *Anas poecilorhyncha, Ardeola bacchus, Egretta garzetta, e. intermedia, E. alba*	Protected area as a National Mangrove Protection Area: ➢ Woodcutting and hunting prohibited ➢ Mangrove restoration programme

China (con't)

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Qinglan Gang and Wenchang, Hainan: Consist of brackish marshes, extensive mangrove swamps, intertidal mudflats, sandy beaches and coral reefs	5,733 ha	Fisheries	➢ Densely populated ➢ Overfishing	➢ 25 mangrove species ➢ breeding area for Ardeidae; wintering and staging area for migratory shorebirds	3,733 ha is protected as the Qinglan Gang Mangrove Nature Reserve: ➢ no felling allowed ➢ reforestation program
Yanpu Gang, Hainan: Brackish marshes, mangrove swamps, tidal mudflats, sandy beaches and coral reefs	1,200 ha	Fisheries	➢ Domestic sewage from dense population ➢ Inland agriculture	➢ Mangrove forest ➢ Wintering and staging area for migratory shorebirds	None
Tiehshan Gang and Anpu Gang, border of Guangxi and Guang-dong Provinces: Small estuaries and shallow bays with intertidal mudflats, mangrove forests, sandy beaches	35,000 ha	Fisheries	➢ Domestic sewage from dense population ➢ Inland agriculture	➢ Large tracts of mangrove forests ➢ Wintering and staging area for migratory shorebirds	None
Qingzhou Wan, Guangxi Province: Large shallow bay receiving Qinliang River, several small bays and estuaries, small offshore islands, extensive intertidal mudflats and patches of mangrove forests	36,000 ha of coastal flats and mangroves ; 8,385 ha of islands	Fisheries	No information	➢ Flora: mangrove and seagrass beds ➢ *Dugong dugon*	None

China (con't):

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Wetlands in the Dayao Shan Nature Reserve, Guangxi Province: small freshwater lake and marshes, and a fast-flowing river and associated marshes	Nature reserve: 14,500 ha; Wetland area unknown	No information	No information	➢ No information on flora ➢ Breeding area for *Shinisaurus crocodilurus*	Wetlands protected in the Dayao Shan Nature Reserve (14,500 ha) since 1982.
Dawangling Marshes, Guangxi Province: estensive riverine marshes and large area of rice paddies on marshy plain	19,200 ha	No information	No information	➢ Riverine marshes and rice paddies ➢ Wintering area for migratory waterfowl	Potected in a Nature Reserve establishes in 1980.
Chengbi He Reservoir, Guangxi Province: large water storage reservoir and associated marshes on a tributary of the Yong Jiang River; several small islands	16,200 ha	No information	No information	➢ No information on flora ➢ Wintering area for migratory waterfowl	Protected in a Nature Reserve established in 1980

Country: Indonesia

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Ogan-Komering Lebaks, South Sumatra: Freshwater swamps and marshes along the Ogan and Komering Rivers	200,000 ha	No information	Reclamation for agriculture resulting in deforestation	➢ No information on flora ➢ Rich in waterbirds including the endangered white-winged wood duck *Cairina scutulata*	None
Padang-Sugihan Wildlife Reserve, South Sumatra: Peat swamp forest, sampy grassland, rivering swamp forest and drier *Melaleuca* forest, all of which are periodically flooded; east and west borders of the reserve are the Sugihan and Padang Rivers, resp, and which are very acidic and heavily stained with tannins, among others	75,000 ha	Conservation education	➢ Illegal logging in the swamp forest ➢ Poaching of the Sambar deer and monitor lizards ➢ Clearance for settlement	➢ Dominant vegetation are those in the peat swamp forest; with abundant ferns and orchids ➢ Many species of waterfowl including the endangered white-winged wood duck *Cairina scutulata,* the rare Storm's stork *Ciconia stormi;* 11 species of kingfisher; raptorial birds include *Haliastur indus, Haliaeetus lecogaster, Ichthyophaga nana and I. Ichthyaetus,* and fish owl *Ketupa ketupo* Mammalian fauna: *Panthera tigris sumatrae, felis bengalensis, F. viverrina, elephas maximus sumatranus, Helarctos malayanus, Lutra sumatrana, Aonyx cinerea, Paguma larvata, Cynogale bennettii, Hylobates agilis, Macaca nemestrima, M. fascicularis, Presbitys cristatus, Tragulus napu, T. javanicus, Sus scrofa, S. barbatus, Cervus unicolor*	Declared as a Wildlife Reserve (75,000 ha)

Indonesia (con't)

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Pulau Betet, South Sumatra: Large island with mangrove forests, intertidal mudflats and peat swamp forests	About 10,000 ha	Important as nursery ground for fish and shellfish	➢ Illegal logging ➢ Collection of eggs of waterbirds for food	➢ Mangrove forest dominated by Rhizophora and Bruguiera ➢ Important area for resident and migratory waterfowl; at least 30 species ➢ Estuarine crocodile *Crocodylus porosus*	None
Banyuasin Musi River Delta, South Sumatra: Large delta system of the Banyuasin and Musi rivers with extensive mangrove systems, intertidal mudflats	150,000 to 200,000 ha	➢ Fisheries especially shrimps and prawns, and cockles ➢ Timber	➢ Reclamation ➢ Logging ➢ Disturbance of breeding colonies of waterbirds ➢ Hunting ➢ Forest fires	➢ Over 30 species of mangrove; freshwater swamp forests, peat swamp forests, and grassy marshes ➢ 18 species of large waterbirds and 20 species of migratory shorebirds; 3 species of birds of prey ➢ 10 mammal species ➢ *Crocodyllus porosus,* turtle *Chitra indica, Pelochelys bibronii*	None
Sungai Lalan, South Sumatra: Extensive mangrove swamps and intertidal mudflats	586,417 ha including 80,000 of swamp forest	Fisheries	➢ Logging ➢ Forest clearance for transmigration schemes ➢ Crocodile hunting ➢ Pollution and disturbance from boat traffic	➢ Mangrove, freshwater swamp and peat swamp forest species ➢ At least 12 fish species; unknown number of waterfowl species; about 5 mammal species; 5 reptile species	None

Indonesia (con't)

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Berbak Game Reserve, Sumatra: One of the largest swamp forest reserves, both peat and freshwater types.	175,000 ha	➢ Unique Kubu tribe of hunter-gatherers ➢ Peat swamp is an important natural water storage during dry season	➢ Drainage of the peat swamp by drainage canals ➢ Illegal logging ➢ Disturbance of the roosts of migratory shorebirds ➢ Capture of freshwater turtles ➢ Forest fires	➢ 150 species of trees ➢ at least 34 species of freshwater fishes and brackishwater water fishes ➢ at least 24 species of shorebirds ➢ about 21 mammal species ➢ at least 16 reptile species	Protected as a game reserve since 1935
Kerumutan Baru, Riau Province: large reserve with extensive peat swamp forests and a small area of dry-land forest; with about 5 rivers crossing through it.	120,000 ha	No information	➢ agricultural encroachment ➢ Illegal hunting ➢ Logging	➢ Peat swamp forest with wet lowland forest ➢ At least 7 mammal species ➢ Unknown number of waterfowl species	Protected as a Nature Reserve (Cagar Alam)
Danau Bawah and Pulau Besar, Riau Province: Peat swamp forests with two freshwater lakes and an island in one of the lakes.	23,750 ha	➢ High aesthetic values ➢ Rich genetic resources	➢ Land clearance for transmigration ➢ Logging ➢ Oil exploration ➢ Road construction	➢ Extensive *Shorea* and *Gonstylus bancanus* swamp forests ➢ Rich in wildlife	Protected as a nature reserve since 1979
Siak Kecil, Riau Province: System of small freshwater lakes in a large area of peat swamp and freshwater swamp forests	c. 100,000 ha	No information	➢ Logging ➢ Oil exploitation	➢ 30 species of peat swamp trees ➢ unknown no. of waterfowl species ➢ important habitat for rare and endangered mammals ➢ breeding area for false gharial *Tomistoma schlegelii*	None

Indonesia (con't)

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Bakau Selat Dumai, Riau Province: large area of rich and undisturbed mangrove forest and peat swamp forest.	60,000 ha	Fisheries	➢ Settlements ➢ Logging	➢ Mangrove and peat swamp tree species ➢ Rich in waterbirds and wildlife; no species inventory	None
Ijen Merapi Ungup, East Java: A small crater lake with many sulphur fumerols, 50 ha in area; most with climax forest.	Nature reserve is 2,560 ha	Area of geological and botanical interest	➢ Manmade fires ➢ Sulphur mining ➢ Intense agriculture	➢ With lowland and montane forests; grasslands ➢ Rich fauna but information is little	Nature reserve established in 1920
Pleihari Tanah Laut, South Kalimantan: low-lying coastal area with 40% grassland and shrub land and 50% swamp	35,000 ha	➢ Fisheries ➢ Water supply	➢ Wood cutting ➢ Hunting of deer ➢ Shifting cultivation ➢ Grazing of domestic livestock	➢ Mangrove forests, grasslands and swamp forest, heath forest ➢ Waterfowl and migratory shorebirds ➢ Mammals ➢ Marine turtles, estuarine crocodile and monitor lizard	Protected as a Wildlife Reserve since 1974
Danau Bankau and other swamps in Barito Basin, South Kalimantan: Alluvial plain of the lower Barito Basin; complex system of levees and back-swamps, deep water swamps; peat swampts; two open water lakes Danau Bankau and Danau Panggang	480,000 ha	➢ Deep water swamps for natural flood control ➢ Fisheries	➢ Reclamation ➢ Fishing ➢ Reed cutting ➢ Bird trapping ➢ Forest clearance	➢ Most important freshwater swamp in Kalimantan ➢ Very important area for waterbirds (at least 27 species)	None
Kelompok Hutan Kahayan, Central Kalimantan: large area of swamp forest (peat, freshwater, mangrove)	150,000 ha	➢ Marine fisheries	➢ Timber cutting ➢ Forest clearance for agriculture	➢ Mangrove forest, freshwater and peat swamp forests ➢ No information on fauna	None

Indonesia (con't)

Site description	Area	Economic &	Disturbances	Biodiversity	Conservation

		social values	& threats		measures taken
Tanjung Putting National Park, Central Kalimantan: vast low lying area of mangrove, peat and freshwater swamp forests and kerangas forest	Area of wetlands unknown; 296,800 ha out of official area of 300,040 ha has been mapped	Important genetic resource	➢ Illegal cutting ➢ Illegal hunting and fishing ➢ Poaching of waterfowl eggs	➢ Mangrove, peat and freshwater swamp species, kerangas forest ➢ Very rich fauna	Protected as a Biosphere Reserve in January 1977 and a National Park in October 1982
Tanjung Penghujan, Central Kalimantan: swampy coastal area bordered by a fringe of mangrove forest and backed by freshwater swamp forest	40,000 ha	High potential for outdoor creation	Tree felling for wood	➢ Mangroves and freshwater swamp forest ➢ Rich wildlife, but little information; proboscis monkey *Nasalis larvatus* present	None
Muara Kendawangan, West Kalimantan: complete seral succession of lowland habitats from coastal sand bars, mudflats and mangrove forest through swamp forest to dry lowland forest	c. 150,000 ha: 75,000 ha of freshwater swamps; 65,000 ha of peat swamps; 10,000 ha of mangroves	No information	None known; uninhabited	➢ Mangrove, freshwater and peat swamp forests ➢ Rich in wildlife including mammals and birds	None; proposal for establishing a Nature Reserve approved but not implemented

Indonesia (con't)

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Gunung Palung and surrounding swamps, West Kalimantan: relatively undisturbed hill and lowland forest including mangroves, freshwater swamp forest, peat swamp forest and wet lowland forest on alluvium.	c. 130,000 ha: 7,000 ha mangrove forest; 20,000 ha of freshwater swamp forest; 30,000 ha peat swamps; 5,000 ha wet lowland forest; 62,000 ha moist lowlar dipterocarp forest; 1,000 ha montane forest; 5,000 wet hill forest	➢ High potential for outdoor recreation ➢ conservation education	➢ Logging ➢ Shifting cultivation	➢ Mangroves, freshwater and peat swamp forests, wet lowland forests ➢ 192 species of birds ➢ mammals: 2 insectivore sp; 4 chiropteran sp, 7 primate sp, 7 rodent sp, 2 carnivore sp, 5 ungulate sp. ➢ 3 reptile sp	A Na ture Monument 30,000 ha in area was estabished in 1930's; upgraded to Nature Reserve and renotified in 1981; proposal to extend to a total area of 100,000 ha made
Hutan Sambas, West Kalimantan: lowland forest including mangrove forest, 100 ha of beach forest; peat swamps and moist lowland dipterocarp forest	120,000 ha: 43,000 ha of mangrove forest; 100 beach forest; rest are peat swamps and moist lowland dipterocarp forest	➢ potential for an international reserve linking up with Samunsam Reserve in Sarawak	➢ Uncontrolled logging ➢ Hunting ➢ Poaching of sea turtle eggs ➢ Shifting agriculture	➢ Mangrove forest, peat swamp forest, freshwater swamp forest, moist lowland dipterocarp forest ➢ Rich in wildlife; large and important sea turtle nesting beaches	None

Country: Malaysia

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Southeast Pahang Swamp Forests, Pahang: swamp forest consisting of peat swamps, freshwater swamps	325,000 ha including at least 90,000 of peat swamp forests	➢ Flood mitigation ➢ Water reservoir ➢ Timber source ➢ Gene pool for commercially important plant species	➢ Reclamation for agriculture and development ➢ logging	➢ largest contiguous area of peat swamp forest ➢ most lowland forest animals occur ➢ birds include 4 sp of hornbills, 5 sp of kingfishers ➢ pythons and freshwater turtles	80,000 ha of swamp forest are Forest Reserves
Sedili Kecil Swamp Forest, eastern Johor: seasonally flooded freshwater swamp forest	c. 5,000 ha	➢ Considerable timber value ➢ Flood mitigation ➢ Scientific interest	➢ Logging ➢ Aquaculture development	➢ Freshwater swamp forest ➢ No information on fauna	Most of the area falls within the Chandangan Forest Reserve
Klias Peninsula, Sabah: Continuous flat area of peat swamp, freshwater alluvium, and mangroves	90,000 ha: 60,700 ha of peat swamp; freshwater alluvium of 14,500 ha; coastal transitional swamp (28,500 ha); mangrove (14,500 ha)	➢ Fisheries including finfish and prawns ➢ Commercially valuable timber	Logging	➢ Coastal mangrove forest, nipa swamp, freshwater and peat swamp forest, grassland Supports highest known concentration of migratory ducks	Five forest reserves were established with a total area of 31,053 ha; In 1980, 30,900 ha of national park were degazetted
Tempasuk Plain, Sabah: freshwater wetland	Over 13,000 ha including 12,200 ha in Kota Belud Bird Sanctuary	➢ Rice-growing and livestock production ➢ High potential for tourism and scientific research	➢ Large-scale drainage of the swamp for agriculture ➢ Conversion of grazing land to aquaculture ponds ➢ Illegal hunting ➢ Shifting cultivation	➢ Outstanding variety of wetland habitats ➢ Waterfowl: 14 sp of herons and egrets; 7 sp of ducks, 8 sp of rails and crakes; 30 sp of shorebirds, 8 sp of terns	12,200 ha protected as Kota Belud Bird Sanctuary

Malaysia (con't)

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
The Lower Reaches of the Baram River System, Sarawak: a major river with large catchment area; large areas of peat swamp forest; most highly developed peat swamps	300,000 ha	➢ Fisheries ➢ Flood control thorugh the domed peat swamps	➢ Infrastructure for flood control ➢ Hunting of wildlife ➢ logging	➢ most highly developed peat swamp ➢ 43 sp of fishes ➢ rare reptiles	Entire area is included in State Forest Reserves
Loagan Bunut, Sarawak: seasonal freshwater lake, Loagan Bunut (Sarawak's largest freshwater lake) and surrounding areas of seasonally flooded forest	19,000 ha	➢ Fisheries ➢ Potential for rotational forestry, provided rotation period were not less than 70 years	➢ Logging ➢ Intensive fishing ➢ Disturbance because of road access	➢ No information on flora ➢ At least 10 sp of fish ➢ Breeding colonies of *Phalacrocorax carbo* and *Anhinga melanogaster*	Forests are protected in the Lower Baram Forest Reserve and Marudi Forest Reserve
Third Division Swamp Forest, Sarawak: a vast tract of peat swamp forest, much of which is production forest that is largely exploited	340,000 ha	➢ Domed peat swamps are natural flood mitigation structures ➢ Valuable timber source	➢ Overexploitation of the peat swamp forest ➢ Forest conversion for alternative uses	➢ Peat swamp forest of various types; mangrove forest ➢ No information on fauna	All within Protected Forests and Forest Reserves
Matu-Daro and Sibu Swamp Forest, Sarawak: a large block of peat swamp forest with coastal mangroves and nipa	267,000 ha	Mangroves support important commercial inshore and offshore fishery	➢ Tree felling for woodchips ➢ Reclamation for agriculture	➢ Mangrove forest, nipa swamp, peat swamp forest ➢ Important for migratory shorebirds	Most of the area is within Protected Forests

Malaysia (con't)

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Maludam Swamp Forest, Sarawak: a peninsula of flat peat swamp forest between the Saribas, Layar and Lupar Rivers	c. 125,000 ha	➢ Source of timber ➢ Peat swamp important in flood mitigation ➢ Freshwater fishery	Non-sustainable logging	➢ Virgin peat swamp forest ➢ Important for migratory shorebirds ➢ Important for the red, black and white form of the banded langur *Presbytis melalophos cruciger*	About 26,500 ha of forest are included in the Triso Protected Forest and 16,800 ha in the Maludam Forest Reserve
Sadong Swamp Forest, Sarawak: large expanse of flat low-lying peat swamp forest drained by the Batang Sadong and the Sungei Simunjan	17,200 ha	➢ Valuable source of timber ➢ Peat swamps for flood control	Overexploitation of forest resources	➢ Peat swamp forest and mixed dipterocarp forest ➢ Occurrence of orang-utans *Pongo pygmaeus,* endangered flat headed cat *Felis planiceps* and the earless monitor lizard *Lanthanotus borneensis*	The whole site is within the Sadong Forest Reserve
Samunsam Wildlife Sanctuary, Sarawak: entire water catchment area of the Samunsam River from the mangrove and nipa swamps of the lower reaches through kerangas and mized dipterocarp forest	20,902 ha	➢ Mangroves support important fisheries ➢ Valuable source of timber and charcoal	➢ Clearance of kerangas for agriculture ➢ Timber exploitation ➢ Infrastructure for power and transportation	➢ 6 types of mangrove forests ➢ empran forests, mixed dipterocarp lowland rainforest and kerangas forest ➢ 24 sp of freshwater species; 240 species of birds of which 50 species are waterfowl sp. ➢ 70 sp of mammals, including 4 rare species ➢ 35 sp of reptiles ➢ 20 sp of amphibians	6,092 ha protected as Samunsam Wildlife Sanctuary in 1979.

Country: Philippines

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Buguey wetlands, Cagayan, northern Luzon: a complex of coastal lagoons, freshwater marshes, brackish and saline marshes, mangrove swamps and intertidal mudflats; located east of the mouth of Cagayan River.	c. 14,400 ha (about 80% of Buguey municipality)	➢ Fisheries ➢ Rice production	➢ Conversion to shrimp and fish ponds ➢ Hunting of waterfowl ➢ Pesticide pollution from agriculture	➢ nipa swamp, mangrove species and *Ipomoea reptans* ➢ important staging and wintering area for migratory waterfowl	None
Pangasinan wetlands, Central Luzon: large area of fish ponds and rice paddies with adjacent intertidal mudflats; over 10 rivers and creeks, all branches of the Agno River, run through the wetland and drain into Lingayen Gulf; lies at the edge of the alluvial plains of Central Luzon	c. 3,000 ha	➢ Fisheries ➢ Rice production ➢	Mangrove loss in favor of aquaculture	➢ remnants of mangrove ➢ 20 species of shorebirds	Mangrove revegetation project was launched in 1987.
Candaba swamp, Central Luzon: a complex of freshwater ponds, swamps and marshes with seasonally flooded grassland, arable land and palm savanna on a vast alluvial flood plain	32,000 ha	➢ Agriculture ➢ Fisheries production ➢ Flood control ➢ Source of irrigation water ➢ Local spot for bird watchers and naturalists	➢ Conversion into fishponds ➢ Drainage to increase agricultural area ➢ Illegal hunting of waterfowl	➢ Patches of nipa and mangrove swamps ➢ 60 species of birds which feed and roost in the swamp area	None

Philippines (Con't)

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Laguna de Bay, Luzon: Largest lake in the Philippnes with a shoreline of aboutr 220 km; drains through the Napindan Channel into the Marikina River which joins the Pasig River and out into Manila Bay; highly eutrophic; fed by 21 small rivers and streams, with the total inflow allowing for flushing the lake once a year	Watershed area is 382,000 ha excluding the area of the lake	➢ Fisheries ➢ Source of potable freshwater	➢ Freshwater aquaculture leading to high organic loading and deteriorating water quality ➢ Conflict between aquaculture and capture fisheries ➢ Industrial, agricultural and domestic pollution ➢ Extensive reclamation for industrial, residential and recreational estates ➢ Deforestation	➢ *Eichhornia crassipes,* marsh vegetation ➢ 23 native fish species belonging to 16 families ➢ wide variety of waterfowl	➢ Haribon Foundation launched a "Save the Lake Movement" ➢ No protected areas have been established
Taal Lake, Luzon: a large caldera lake with an island; lake is fresh and oligotrophic; fed by a number of streams rising on the Tagaytay Ridge and drains into Pansipit River which flows out to Balayan Bay.	23,424 ha	➢ Recreation ➢ Fisheries	➢ Urban encroachment ➢ Siltation ➢ Introduction of exotic fish species ➢ Volcanic activity	➢ Lake flora ➢ Rich crustacean, molluscan and fish fauna and a number of which are is endemic	➢ Volcanic island is a National Park established in 1967 ➢ Lake itself is not protected
Lake Manguao, Palawan: A very deep freshwater lake fed by several small rivers and local run-off	643 ha	No information	No information	➢ No information on flora ➢ *Crocodylus porosus* is believed to occur in the lake	The whole of Palawan Island has been declared a wildlife preserve

Country: Thailand

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Yom River Floodplain, northern Thailand: extensive alluvial basin; intensively cultivated; scattered are many small permanent swamps	c. 50,000 ha	➢ Major recreational area ➢ Fish farming	➢ Illegal hunting of waterbirds ➢ Intensive agriculture ➢ Flood control works	➢ Natural grassland, mixed deciduous or dry dipterocarp woodland ➢ Duck migration area	➢ Nong Nam Kao Non-Hunting Area (57.3 ha) established
Beung Si Fai, northern Thailand: a permanent, freshwater lake, its associated marshes and adjacent rice paddies; fed by overspill from the River Nan during the late rainy season	810 ha	➢ Recreation and tourism ➢ Lake a major social amenity	None known	➢ Small areas of *Arundo donax* and *Cyperus spp.* ➢ Wintering waterfowl	Fishing is not allowed in 24 ha of the lake
Beung Boraphet, northern Thailand: a large freshwater lake along the east bank of the Mae Nam Nan; surrounded by rice paddies; formed in 1930 by the damming of a freshwater swamp in order to develop the fishery	13,000 ha	➢ Fisheries ➢ Source of irrigation water ➢ Tourism	➢ Harvest of emergent vegetation including *Phragmites* ➢ Illegal trapping of waterfowl ➢ Agricultural pollution including pesticides	➢ Dense mats of floating vegetation ➢ Important site for wintering ducks in Thailand	About 45,000 ha including the lake and surrounding paddy declared as a Non-Hunting Area in 1975.
Southern Central Plains, central Thailand: huge area of intensively cultivaled land with numerous small lakes and marshes; plains received water from four major rivers: the Bang Pakong, Chao Phraya, Tachin and lower reaches of the Mae Klong.	1,900,000 ha	➢ Agriculture ➢ Aquaculture of *Macrobrachium* ➢ Waterways for communication and transport	➢ Conversion of marginal areas to agriculture ➢ Reclamation for settlement	➢ Mats of low grasses, floating aquatic vegetation ➢ Important breeding area for waterfowl and roost for wintering birds	➢ About 360 ha of non-hunting areas ➢ Some receive *de facto* protection, such as those near temples or they are within private land

Thailand (con't)

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken

Khao Sam Roi Yot NationalPark, southern Thailand: an area of coastal marshes, paddies; includes the largest freshwater marsh in Thailand (6,000 ha)	13,000 ha	➢ Freshwater and brackishwater fisheries ➢ Tourism	➢ Aquaculture ➢ Encroachment by agriculture ➢ Illegal hunting of wildlife ➢ Tourism	➢ Dominant freshwater marsh flora is *Phragmites australis;* mangroves, mixed deciduous forest ➢ 237 sp of birds	Most of the area protected as a National park
Tapi River and Nong Tung Tong Non-Hunting Area, southern Thailand: a complex of swamps and grasslands along the Tapi River; principal inflow from the catchment of the Tapi River	6,450 ha	➢ Fisheries ➢ Cattle grazing ➢ Source of irrigation water	➢ Gradual intensification of agriculture ➢ Man-made burning of grasslands ➢ Illegal hunting	➢ emergent aquatic plants; lowland evergreen scrub forest	An area of 2,960 ha declared as the Nong Tung Tong Non-Hunting Area in 1975
Thale Noi Non-Hunting Area, southern Thailand: a roughly circular lake surrounded by open swamp vegetation, sedge beds and rice paddies, and an extensive *Melaleuca* swamp forest	*Melaleuca* forest covers 4.220 ha; grasslands and sedge beds, 10,870 ha; lake area is 30,000 ha	➢ Fisheries ➢ Harves of aquatic plants ➢ Capture and sale of snakes ➢ Tourism	➢ Contnued clearance of *Melaleuca* for charcoal ➢ Illegal hunting of wildlife, and their eggs ➢ Domestic and agricultural waste	➢ Floating and emergent plants; marsh vegetation; *Melaleuca* woodland ➢ 186 sp of birds ➢ otter *Lutrra sp* and terrapin *Balangur baska* occur	A non-hunting area; *Melaleuca* forest is a National Reserve Forest where cutting is forbidden
Lake Songkhla, southern Thailand: a huge shallow coastal lagoon of fresh to brackish water which opens to the sea by a narrow channel; fed by 1000 streams and drains 8,000 km^2 of catchment	104,000 ha	➢ capture and culture fisheries ➢ Recreational and educational values	➢ Industrialization and development ➢ Illegal hunting ➢ Burning or cutting of emergent vegetation ➢ Pumping of irrigation water causing salinity intrusion	➢ 40 sp of edible fish ➢ 29 sp of aquatic plants ➢ 48 species of land plants ➢ 140 sp of birds ➢ river terrapins and otters	Thale Sap Non-Hunting Area covers 31,500 ha
Pa Phru, southern Thailand: a large depression supporting 9,700 ha of primary peat swamp forest near 14,600 ha of *Melaleuca* woodland and scrub; and 9,800 of degraded grasslands	c. 34,600 ha	➢ Harvest of forest products ➢ Research and educational use ➢ Culturally ethnic population	➢ Drainage to minimize flooding ➢ Unsustainable development projects ➢ Cutting and burning to free up land for agriculture	➢ Over 50 plant species reported as new to thailand; 66 tree species in 29 families ➢ 16 sp of fish lowland forest birds, mammals and reptiles	16,000 ha as Non-Hunting Area; remaining forest as National Reserve Forest

Country: Viet Nam

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken

Ba Be Lake, Cao Bang Province: freshwater lake in a limestone mountain area, connected to the Nang River by a channel	450 ha	➢ Regulates water supply ➢ Tourism	Illegal hunting	➢ Tropical rain forest, mountain lake vegetation ➢ 17 native sp of fish ➢ 100 sp of birds ➢ 30 sp of mammals	Declared a National Park in 1985
Thac Ba Reservoir, Hoang Lien Son Province: large water storage reservoir	23,400 ha	➢ Water for irrigation and power generation ➢ Fisheries	Siltation	➢ Reed beds, marsh grasses and low shrubs ➢ Migration route of waterfowl	➢ Restrictions on cultivation along the steep slopes ➢ Reafforestation
Chu Lake, Vin Phu Province: small natural freshwater lake fed by the Van and Thoi streams	300 ha	Small fisheries	No information	➢ Aquatic plants and marsh grasses, shrubs ➢ Waterfowl migration	No information
Chinh Cong, Vin Phu Province: small, natural freshwater lake in the Red River Basin fed by Ca and Ky streams	400 ha	➢ Agriculture ➢ Irrigation ➢ Aquaculture	➢ Drainage for agriculture ➢ Overexploitation	➢ Aquatic plants ➢ Important wintering area for migratory waterfowl	None
Nui Coc Reservoir, Bac Thai Province: water storage reservoir constructed in 1977 on the Cong River, a tributary of the Red River	2,580 ha	➢ Fisheries ➢ Irrigation ➢ Outdoor recreation	➢ Forest clearance for wood, construction and agriculture ➢ Heavy grazing by livestock	➢ Aquatic vegetation, shrub and secondary forest ➢ 10 native fish sp ➢ 40 sp of birds ➢ 15 sp of mammals	➢ Protected Area as of 1985 ➢ Reafforestation program around reservoir
Vac Swamp, Vin Phu Province: a freshwater swamp fed by the Ca Lo and Cau Bon Rivers in the Red River Basin	250 ha	➢ Small fisheries ➢ Irrigation ➢ Resort area	No information	➢ Aquatic plants, marsh grasses ➢ No information on fauna	A reserve covering the swamp has been established

Viet Nam (con't)

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Song Da Reservoir, ha Son Binh Province: a large water storage reservoir constructed	72,800 ha	➢ Power generation ➢ Irrigation	Cultivation on steep slopes of the catchment area	Too young and of little value to wildlife	➢ Water catchment area is protected ➢ Reafforestion

in 1985 on the Da River for power generation, irrigation, aquaculture and water regulation		➢ Major fisheries ➢ Tourism			around the reservoir
Ho Tay, Hanoi: natural freshwater lake on the south bank of the Red River	413 ha	➢ Fisheries ➢ Recreation	➢ Pollution ➢ Reclamation for urban development	➢ Aquatic plants, marsh vegetation ➢ Staging and wintering area for migratory birds	Restrict waste water inflow into the lake
Cam Son Reservoir, ha Bac Province: a water storage reservoir made in 1960 by a dam on Hoa River, a tributary of the Thuong River	2,620 ha	➢ Power generation ➢ Fisheries	Use of poisons and explosives to catch fish	➢ Sanctuary for native stream fishes ➢ Migratory waterfowl	Reafforestion in the water catchment area
Ke Go Reservoir, Nghe Tinh Province: water storage reservoir on the Ba Mo River	2,500 ha	➢ Irrigation ➢ Fisheries ➢ Hydropower	Cultivation of cassava and other crops causing siltation	Migratory waterfowl	➢ Restrictions on cultivation ➢ Reafforestation
Bau Xen Lake, Binh Tri Thien Province: a small freshwater lake 4 km from the sea	200 ha	➢ Irrigation ➢ Fisheries ➢ Water supply ➢ Recreation	No information	Migratory waterfowl	None
Bien Ho Lake, Lai-Kontum Province: natural freshwater lake on a high plateau formed by 3-4 volcanic craters	600 ha	➢ Small fisheries ➢ Potable water source ➢ Irrigation	➢ Siltation ➢ Oil pollution from motor boats	➢ Rich fish fauna ➢ Variety of waterfowl	➢ Measures taken to maintain water quality ➢ Replanting of bare hillsides

Viet Nam (con't)

Site description	Area	Economic & social values	Disturbances & threats	Biodiversity	Conservation measures taken
Lak Lake, Dak Lak Province: a natural freshwater lake in the swamp region of the Dak Lak High Plateau	500 ha	➢ Small fisheries ➢ Irrigation	Siltation because of shore cultivation	➢ Reed beds, swamp vegetation ➢ waterfowl	None
Nam Cat Tien, Dong Nai Province: small permanent freshwater lake and a large area of seasonal lakes and marshes	2,500 ha	Potential for scientific research, conservation education and tourism	➢ Excessive hunting ➢ Manmade fires ➢ Population growth and consequent exploitation	➢ Grassland, swamp forest, humid evergreen forest, semi-evergreen and deciduous forest; 62 sp of orchids ➢ Resident and migratory waterfowl ➢ Mammals and reptiles	Wetland and surrounding forests are protected in the Nam Cat tien Forest Reserve (36,500 ha) established in 1978.
Bien Lac, Thuan Hai Province: a group of natural freshwater lakes and associated marshlands, surrounded by seasonally flooded grassland and forest	2,000 ha during wet season	Fisheries	Overexploitation of living resources	No information on flora and fauna	Protected Area covers Bien Lac and surrounding forests, total area of 10,025 ha
Dong Thap Muoi: large area of seasonally flooded alluvial plains on the north bank of the Mekong	300,000 ha	➢ Contains the largest area of floating rice in the Mekong Delta ➢ Fisheries ➢ Natural flood basin	➢ Settlement ➢ Agriculture ➢ Overexploitation of wildlife	➢ Swamp and grassland vegetation; wild rice ➢ Resident and migratory waterfowl ➢ Mammals and reptiles	Tram Chim Sarus Crane Reserve established in 1986 (9,000 ha)
Minh Hai *Melaleuca* Forest, Minh Hai Province: large area of seasonally flooded *Melaleuca* swamp forest	163,000 ha	➢ Timber products ➢ Fisheries ➢ Potential for nature tourism	➢ Manmade fires ➢ Overexploitation of living resources	➢ 40 sp of aquatic plants ➢ 23 sp of mammals ➢ 91 bird sp ➢ 36 reptile sp ➢ 11 sp of amphibians	Vo Doi Protected Forest of 3,945 ha in the U Minh ha forest was established in 1985

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